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ENGINEERING DESIGN HANDBOOK

DESIGN FOR AIR TRANSPORT AND AIRDROP OF MATERIEL

HEADQUARTERS, U.S. ARMY MATERIEL COMMAND

DECEMBER 1967

HEADQUARTERS
UNITED STATES ARMY MATERIEL COMMAND
WASHINGTON, D.C. 20315

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ENGINEERING DESIGN HANDBOOK

DESIGN FOR AIR TRANSPORT AND AIRDROP OF MATERIEL

This pamphlet is published for the information and guidance of all concerned.

(AMCRD-R)

FOR THE COMMANDER:

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Chief of Staff

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PREFACE

The Engineering Design Handbook Series of the Army Materiel Command is a coordinated series of handbooks containing basic information and fundamental data useful in the design and development of Army materiel and systems. The handbooks are authoritative reference books of practical information and quantitative facts helpful in the design and development of Army materiel.

This handbook presents general technical and operational air transport and airdrop requirements and also provides detailed airdrop design criteria. The data and information compiled in this handbook represent the present state-of-the-art. The data and information will be revised as new knowledge becomes available through research, test, and experience.

In the past, airdrop requirements usually were given consideration after the design of an item had been completed and test prototypes fabricated. The item was then adapted to the airdrop environment by utilizing the available provisions and structural members, supplemented by field modifications. Occasionally, the basic design was such that suitable field modifications could not be accomplished and the item was determined incapable of being airdropped.

This handbook has been prepared as an aid to engineers designing equipment or systems for air transport and airdrop, to insure that capability for air transport and airdrop is incorporated into the basic design. Since materiel developed for air transport or airdrop must meet the limitations imposed by the characteristics of the aircraft, a chapter has been included on the statistical/logistical data of Army and Air Force aircraft which are required to air transport or airdrop Army equipment. Certain commercial aircraft which may be utilized to air transport equipment are also included.

This handbook was prepared by Hayes International Corporation under subcontract to the Engineering Handbook Office of Duke University, prime contractor to the Army Research Office - Durham, for the Engineering Design Handbook Series. The information appearing in this handbook was prepared from numerous reports, publications, specifications, and standards. The preparation of this handbook was under the technical guidance of a committee whose membership was comprised of representatives of the Maintenance Directorate, Headquarters U. S. Army Materiel Command, U. S. Army Aviation Materiel Command, U. S. Army Natick Laboratories, U. S. Army Tank-Automotive Command, U. S. Army Test and Evaluation Command, Edgewood Arsenal, Engineer Research and Development Laboratories, Frankford Arsenal and Picatinny Arsenal. Noteworthy contributions were made by the members of this committee whose chairman was Mr. C. W. Wright, representative of the U. S. Army Aviation Materiel Command.

Comments and suggestions on this handbook are encouraged and should be addressed to Army Research Office-Durham, Box CM, Duke Station, Durham, North Carolina 27706.

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LIST OF SYMBOLS

Primary Concepts

A — Area, general (ft^2 or $in.^2$)

a — Acceleration (ft, sec^2)

B — Number of blades in rotor

C — Ratio of reefing-line diameter length to nominal diameter of unreefed canopy $= D_{R_o}/D_o$

C_e — Effective porosity (ratio of outflow velocity to inflow velocity through a porous fabric canopy)

C_{D_o} — Parachute drag coefficient related to the surface area, S_o

$(C_DS)_o$ — Drag area of unreefed canopy (based on C_{D_o}) (ft^2)

$(C_DS)_R$ — Drag area of reefed canopy (ft^2)

c — Constant

D — Diameter, general (ft)

D_c — Diameter, constructed (ft)

D_o — Nominal diameter of unreefed canopy $= \sqrt{4S_o/\pi}$ (ft)

D_p — Projected or inflated diameter of parachute (ft)

D_{R_o} — Skirt diameter of fully inflated canopy (ft)

D_{R_1} — Skirt diameter of reefed canopy (ft)

D_1 — Theoretical diameter of reefed canopy (ft)

d — Distance (ft or in.)

E — Kinetic energy (ft-lb)

e — Factor related to strength loss by abrasion

F — Force (lb)

F_{CD} — Parachute cluster factor

f — Factor related to strength loss by fatigue

G — Level of acceleration compared to gravitational acceleration $= \frac{a}{g}$

g — Acceleration due to gravity (ft/sec^2) (32.2 at sea level)

h — Height (ft)

i — Particular strap providing a forward restraint component

j — Safety factor

k — Radius of gyration (ft)

L — Length (ft)

M — Moment (in.—lb or ft—lb)

m — Mass, general (slug)

N — Total number

n — g-load factor

o — Factor related to strength loss in material from water and water vapor absorption

P — Tractive force, general (lb)

q — Free air stream dynamic pressure (lb/ft^2)

R — Ultimate strength (lb)

RPM — Revolutions per minute

r — Radius, general (ft or in.)

S — Stress (lb/ft^2)

S_o — Surface area of parachute (ft^2 or $in.^2$)

T — Thickness (ft or in.)

t — Time, general (sec)

t_f — Filling time of parachute (sec)

u — Strength loss factor at the connection point of the suspension line and parachute canopy or riser

V — Velocity, general (knots or ft/sec)

v — Volume, general (ft^3 or $in.^3$)

W — Weight, general (lb)

LIST OF SYMBOLS (Cont)

X	Opening shock factor denoting the relationship between maximum opening force and constant drag force
x	Coordinate along X-axis
$\dot{x}$	Horizontal velocity component (ft/sec)
Y	Coordinate along Y-axis
Z	Number of suspension lines
z	Coordinate along Z-axis
α	Angle of attack (degrees)
β	Angular direction of force (degrees)
γ	Density of foamed plastic (lb/ft^3)
A	Small increment (not used alone)
δ	Ratio of skirt diameters = D_{R_1}/D_{R_o}
ϵ	Design strain of cushioning material
θ	Included angle in parachute riser extension (degrees)
λ_g	Geometric canopy porosity (percent)
ρ	Density of air at given altitude (slug/ft^3)
ρ_o	Density of air at sea level (0.00238 slug/ft^3)
σ	Air density ratio $- \dfrac{\rho}{\rho_o}$
τ	Parachute filling time ratio $= \dfrac{t}{t_f}$
ϕ	Angle between platform and horizontal; angle between tiedown strap and platform (radians or degrees)
$\dot{\phi}$	Angular velocity (rad/sec)
$\ddot{\phi}$	Angular acceleration (rad/sec^2)
ω	Natural frequency in rotor blade system (cycle/sec)

Subscripts

a	Average; apparent
b	Suspendedbody
c	Canopy; constructed
D	Drag
d	Deployment
e	Effective
f	Filling; full inflation
i	Inlet; included
o	Nominal
p	Parachute
R	Resultant
r	Radial
s	Instantaneous
T	Total
v	Vertical
w	Weight
x	X-direction
y	Y-direction
z	Z-direction

CHAPTER 1

INTRODUCTION TO THE PROBLEM

1–1 GENERAL

The increased mobility requirements of today's Army have created a demand for resupply that can be attained only through the use of aircraft. Due to the large quantities of supplies and equipment requiring delivery by aircraft, the old method of adapting an item to air transport and/or airdrop after the item design is completed is no longer adequate. The necessary field modifications and the loading problems inherent with that method create excessive man-hour requirements and serve to limit the attainable mobility. It has therefore become necessary that the capability for air transport and airdrop be incorporated into the basic design of materiel having an air transport or airdrop requirement.

In order to utilize available air transport facilities most effectively and economically, there must exist a close relationship between the military characteristics of items of equipment required to be moved by air and the numbers and types of aircraft which can be provided to move them. The development of materiel for air transport and/or airdrop must be related to those aircraft which will be in service at the time of its introduction and for a reasonable time thereafter. It is obviously not feasible to design all items requiring air ,transport and/or airdrop against the limitations of dimensions and weight imposed by the cargo capability of the most advanced type of aircraft available. To do so would eliminate the use of many aircraft which, though less advanced, are still operational arid have an air transport and/or airdrop capability.

1–2 THE PROBLEM OF DESIGNING MATERIEL FOR AIR TRANSPORT

Materiel developed for air transport in Air Force aircraft must meet all limitations imposed by the characteristics of aircraft used in these types of operations. Materiel developed for air transport by Army aircraft must meet the requirements imposed by the characteristics of Army aircraft and helicopters, as well as those imposed by Air Force aircraft. All clearance requirements must be complied with, including angles of approach and departure for wheeled or tracked vehicles. Tiedown provisions of an item must be compatible with the tiedown devices and fittings provided in the maximum number of aircraft that might transport that item, including strengths conforming with applicable restraint criteria.

1–3 THE PROBLEM OF DESIGNING MATERIEL FOR AIRDROP

Materiel developed for airdrop must be designed to meet the requirements imposed by the characteristics and capabilities of the airdrop system with which they will be used. This includes size and weight requirements and requirements for tiedown, extraction, and suspension provisions. The materiel must be able to withstand the environments created during each phase of airdrop, and the sum of the environments created by all phases. Materiel which is airdropped to combat forces must be capable of immediate effective employment.

1–4 THIS HANDBOOK

The requirements necessary to insure an air transport and/or airdrop capability for materiel have been compiled in this handbook. The equipment and systems used in air transport and airdrop have been described, including current methods of loading and securing materiel to the airdrop system and within the aircraft. Each phase of airdrop has been analyzed to present the environments encountered by materiel during airdrop. Air transport and airdrop characteristics and capabilities have been given **for** Army and Air Force aircraft which are required to transport or airdrop Army equipment, and for certain commercial aircraft which may be utilized to air transport equipment.

CHAPTER 2

DESIGN CONSIDERATIONS FOR AIR TRANSPORT OF MATERIEL

SECTION I

METHODS OF CARGO TIEDOWN

2-1 GENERAL

Cargo in an aircraft is subjected to forces resulting from rough air, rough landings, crash landings, and extreme aircraft attitudes. These forces tend to move cargo aft, forward, to either side (laterally), or up from the cargo floor (vertically). The required restraint that must be used to keep cargo from moving forward is called FORWARD RESTRAINT. Aft, lateral, and vertical restraint are similarly named. Restraint criteria are established for each aircraft. Chapter 4 contains the restraint criteria for those aircraft required to air transport Army materiel. Internal cargo restraint criteria for Army fixed-wing and rotary-wing aircraft are contained in AR 705-35[2*].

To provide adequate restraint, it is necessary to know how great the forces acting upon the cargo are likely to be, and the strength that can be expected from the tiedown devices. The required restraint for a cargo load is then determined by multiplying the weight of the cargo by the restraint factor expressed in units of gravity or "g's" for each direction of required restraint. This may be stated as WEIGHT X RESTRAINT FACTOR = REQUIRED RESTRAINT. Example: A unit of cargo weighing 5000 pounds is to be air transported, and the restraint factors for the particular aircraft, for example the C-130, are:

Forward	8 g's
Aft	1.5 g's
Vertical	2 g's
Lateral	1.5 g's

*Superscript numbers refer to References at the end of this Handbook.

The minimum required restraints would be determined by use of the formula:

Weight	x	Restraint Factor	=	Required Restraint
5000 pounds	x	8 g's	=	40,000 pounds forward
5000 pounds	x	1.5 g's	=	7500 pounds lateral and aft
5000 pounds	x	2 g's	=	10,000 pounds vertical

Tiedown devices are provided with each aircraft to secure cargo to the cargo compartment floor and to provide the required restraint to prevent cargo movement. Each tiedown device is rated to withstand a specific load or force[5]. However, the effective holding strength of a device is determined by the rated strength of the device and the manner in which it is employed. The details of securing each cargo item vary with its bulk, weight, configuration, location in the aircraft, and whether or not it is equipped with tiedown provisions. Generally, restraint and reaction loads are minimal when materiel is located at the cg of the aircraft. Procedures for loading equipment and supplies which are to be air landed in U. S. Army and U. S. Air Force aircraft are contained in TM 55-450-9[33].

2-2 EFFECT OF APPLYING RESTRAINT AT ANGLES

Every tiedown device is rated to withstand a force exerted parallel to the tiedown device as shown in view 1 of Fig. 2-1.

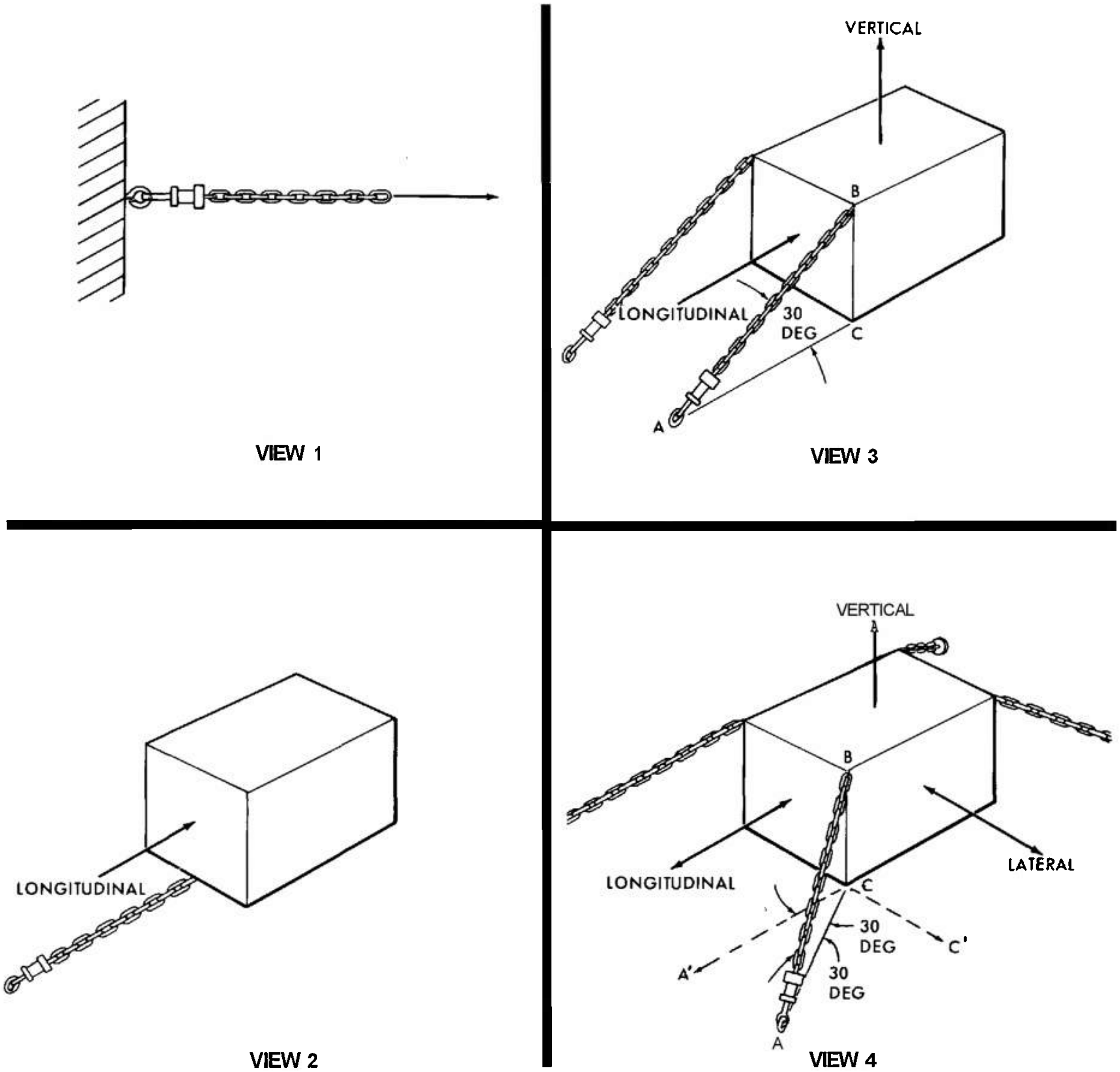


FIGURE 2-1. CARGO RESTRAINT

When one end of a device is secured to a fitting on the cargo floor, the longitudinal (fore and aft) force will not be exerted parallel to the length of the device unless the device is attached to the cargo as shown in view 2. If so attached, all the rated strength will be available to prevent the cargo from moving in the direction of the longitudinal arrow.

Since vertical restraint is not provided with tiedowns fastened as illustrated in views 1 and 2, tiedowns are usually attached at some point above the cargo floor. With the device attached as shown in view 3, approximately 87 percent of the device's rated strength prevents longitudinal movement and 50 percent prevents vertical movement; however, no lateral restraint is provided. A compromise position, as shown in view 4, generally provides restraint simultaneously in four directions: forward, aft, vertical, and lateral.

Tiedown devices attached to a load at a point above the floor form three angles (view 4, Fig. 2—1) that can be measured. These angles are: a floor angle (BAC), a longitudinal plan angle (ACA'), and a lateral plan angle (ACC'). (The term plan angle is used to designate an angle which would be reflected as a true angle in a plan view.) The floor angle (sometimes referred to as the vertical angle) is the angle between the tiedown device and the floor. The longitudinal plan angle is the angle between the tiedown device (A, view 4) and a line (A') which runs fore and aft through point C. The lateral plan angle is the angle between the tiedown device and a line (C') which runs across the cargo compartment through point C. The longitudinal plan angle and the lateral plan angle are complementary angles.

Tiedown devices attached at floor and longitudinal plan angles of 30 degrees provide the best compromise for adequate restraint of cargo in all directions. Frequently, 30-degree angles cannot be used. In these cases, tiedowns are placed as close to a 30-degree angle as possible. Increasing the floor angle while keeping constant plan angles will provide a higher value of vertical restraint, but will reduce the amount of longitudinal and lateral restraint. Keeping the same floor angle but changing the plan angles will not affect the vertical restraint, but will affect the longitudinal and lateral restraint.

Table 2—1 lists the percentages of rated tiedown strength available for vertical, longitudinal, and lateral restraint available at tiedown angles from 5 to 85 degrees.

2—3 CARGO TIEDOWN

The use of tiedown devices to restrain all types of cargo generally follows similar patterns because of the tiedown fitting pattern on the cargo compartment floor. Similar methods are used to restrain all types of cargo, since the basic purpose in each case is to prevent cargo from moving. However, the details of restraining each cargo item vary with its bulk, weight, configuration, and whether it is equipped with

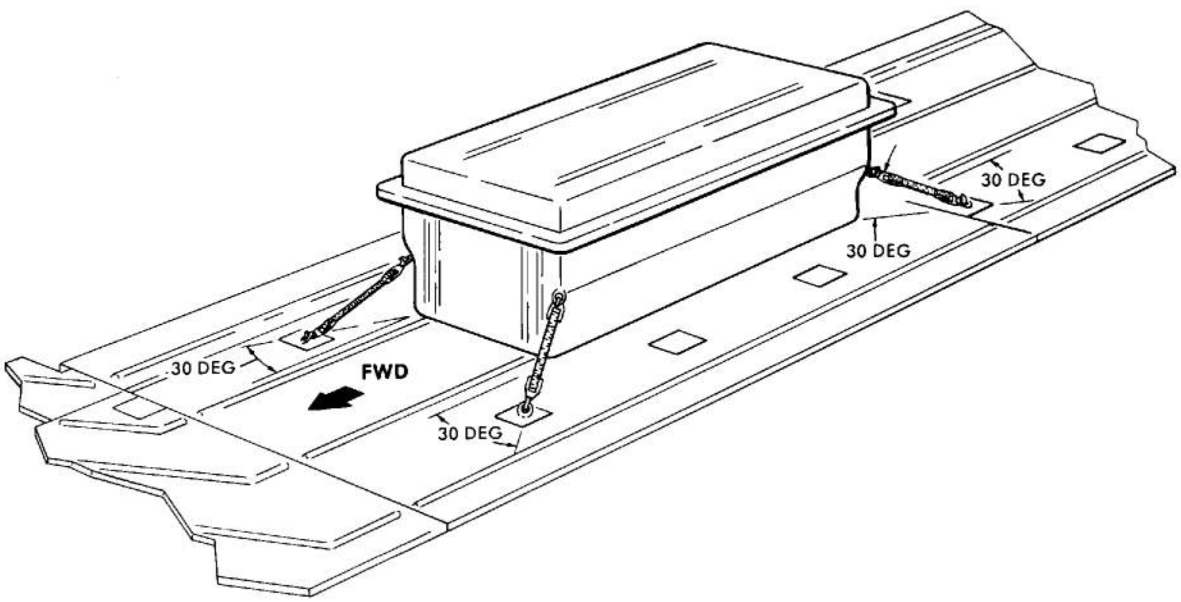


FIGURE 2—2. TIEDOWN ANGLES FOR CARGO WITH TIEDOWN PROVISIONS

TABLE 2–1. PERCENTAGE RESTRAINT CHART

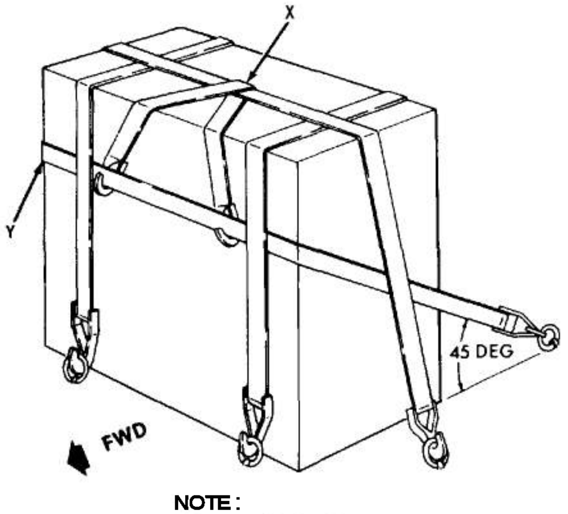
NOTE: 1. Angles across the top are those formed between the tiedown device and the cabin floor.
2. Angles down the side are those formed between the tiedown device and the longitudinal axis of the aircraft.
* Vertical restraint is related only to the angle between the tiedown device and the cabin floor. The lateral angle has no bearing on it.
** The toned area indicates the "best compromise" position.

		5°	10°	15°				35°	40°	45°	50"	55°	50°	55°	70"	76"	80"	86"
	VERTICAL*	8.7	17.4	25.9	34.2	42.3	50.0	57.4	54.3	70.7	76.6	81.9	86.6	90.6	93.9	96.6	98.6	99.6
5°	LONG.	99.2	98.1	95.2	93.6	90.2	86.3	81.5	76.3	70.4	64.0	57.2	49.8	42.1	34.1	26.8	17.3	8.7
	LAT	8.7	8.6	8.4				7.1	5.7	5.2	5.6		4.4		2.9	2.3	1.5	0.8
10°	LONG.	98.1	97.0	95.2	92.6	89.2	85.3	80.7	75.5	59.6	63.3	56.5	49.3	41.7	33.7	25.5	17.1	8.6
	LAT	17.3	17.1	16.8	16.6	15.8	15.1	14.3	13.3	12.3	11.2	4.9	8.7		5.9	4.5	3.0	1.5
15°	LONG.	96.2	95.2	93.3	90.8	87.5	83.7	79.1	73.9	68.3	62.1	55.4	48.3	40.9	33.0	25.0	16.8	8.4
	LAT	26.8	25.5	25.0	24.3	23.5	22.4	21.2	19.8	18.3	16.7	14.9	12.9	10.9	8.9	6.7	4.5	2.3
20°	LONG.	93.6	92.6	90.8	88.4	85.2	81.4	76.9	72.0	66.5	60.4	53.9	47.0	39.8	32.1	24.3	16.6	8.2
	LAT	34.1	33.7	33.0	32.1	30.9	29.6	28.0	26.2	24.2	21.9	19.5	17.1	14.5	11.7	8.9	5.9	2.9
25°	LONG.	90.2	89.2	87.5	85.2	82.1	78.5	74.2	69.4	64.1	58.3	62.0	46.3	38.3	30.9	23.5	15.8	7.9
	LAT	42.1	41.7	40.9	39.8	38.3	36.6	34.6	32.4	29.9	27.2	24.3	11.2	17.9	14.5	10.9	7.4	3.7
30°	LONG.	86.3	85.3	83.7	81.4	78.5	**74.9	70.9	66.3	61.2	55.7	49.7	43.3	36.6	29.5	22.4	15.1	7.5
	LAT	49.8	49.3	48.3	47.0	45.3	43.3	40.9	38.3	35.4	32.2	28.7	25.0	21.2	17.1	12.9	8.7	4.4
35°	LONG.	81.6	80.7	79.1	76.9	74.2	70.9	67.1	62.7	57.9	52.7	47.0	40.9	34.5	28.0	21.2	14.3	7.1
	LAT	67.2	56.5	55.4	53.9	152.0	49.7	47.0	143.9	140.6	35.9	32.9	28.7	24.3	19.5	14.9	9.9	4.9
40°	LONG.	76.3	75.5	173.9	72.0	59.4	55.3	62.7	58.7	54.2	49.3	43.9	38.3	32.4	26.2	19.8	13.3	6.7
	LAT	64.0	53.3	62.1	60.4	58.3	55.7	52.7	49.3	45.5	41.3	35.9	32.2	27.2	21.9	16.7	11.2	6.6
45°	LONG.	70.4	69.5	58.3	66.5	64.1	51.2	57.9	54.2	49.9	45.5	40.6	35.4	29.9	24.2	18.3	12.3	6.2
	LAT	70.4	69.5	68.3	66.5	54.1	51.2	57.9	54.2	49.9	45.5	40.5	35.4	29.9	24.2	18.3	12.3	6.2
50°	LONG.	64.0	63.3	62.1	60.4	58.3	55.7	52.7	49.3	45.5	41.3	35.9	32.2	27.2	21.9	16.7	11.2	6.6
	LAT	76.3	75.5	73.9	72.0	59.4	65.3	62.7	58.7	54.2	49.3	43.9	38.3	32.4	26.2	19.8	13.3	6.7
55°	LONG.	67.2	56.5	55.4	53.9	52.0	49.7	47.0	43.9	40.6	36.9	32.9	28.7	24.3	19.5	14.9	9.9	4.9
	LAT	81.6	80.7	79.1	76.9	74.2	70.9	67.1	62.7	57.9	52.7	47.0	40.9	34.5	28.0	21.2	14.3	7.1
50°	LONG.	49.8	49.3	48.3	47.0	45.3	43.3	40.9	38.3	35.4	32.2	128.7	125.0	121.2	17.1			
	LAT	86.3	85.3	83.7	81.4	78.5	74.9	70.9	66.3	51.2	55.7	49.7	43.3	36.6	29.6	22.4	16.1	
65°	LONG.	42.1	41.7	40.9	39.8	38.3	35.5	34.5	32.4	29.9	27.2	24.3	21.2	17.9	14.5	10.9	8.7	4.4
	LAT	90.2	89.2	87.5	85.2	82.1	78.5	74.2	69.4	64.1	58.3	52.0	45.3	38.3	30.9	23.6	15.8	7.5
70°	LONG.	34.1	33.7	33.0	32.1	30.9	29.6	28.0	26.2	24.2	21.9	19.6	17.1	14.5	11.7	8.9	5.9	2.9
	LAT	93.6	92.6	90.8	88.4	85.2	81.4	75.9	72.0	65.5	50.4	53.9	47.0	39.8	32.1	24.3	16.6	8.2
75°	LONG.	26.8	25.5	25.0	24.3	23.5	22.4	21.2	19.8	18.3	15.7	14.9	12.9	10.9	8.9	6.7	4.6	2.3
	LAT	96.2	95.2	93.3	90.8	87.5	83.7	79.1	73.9	58.3	52.1	55.4	48.3	40.9	33.0	26.0	16.8	8.4
80°	LONG.	17.3	17.1	116.8	16.6	15.8	15.1	14.3	113.3	12.3	11.2	9.9	8.7	7.4	5.9	4.6	3.0	1.6
	LAT	98.1	97.0	195.2	92.6	89.2	85.3	80.7	175.5	169.6	63.3	56.5	49.3	41.7	33.7	25.5	17.1	8.6
85'	LONG.	8.7	8.6	8.4	8.2	7.9	7.5	7.1	6.7	6.2	5.6	4.9	4.4	3.7	2.9	2.3	1.6	0.8
	LAT	99.2	98.1	96.2	93.6	190.2	86.3	81.6	76.3	70.4	64.0	157.2	149.8	142.1	34.1	25.8	17.3	8.7

tiedown provisions. Detailed design requirements of tiedown fixtures required for military equipment for air transport are contained in MIL-STD-209[42]. Design provisions for materiel designed for airdrop are contained in MIL-STD-814A[5].

2—3.1 CARGO WITH TIEDOWN PROVISIONS. When a tiedown device is attached directly to a cargo unit, restraint can be applied simultaneously for more than one load direction by varying the angle of attachment. Some items of equipment and general cargo are designed with suitable points to which cargo tiedown devices can be attached, as shown in Fig. 2—2. The 30-degree angle of tie should be used when possible.

2-3.2 CARGO WITHOUT TIEDOWN PROVISIONS. This type of cargo is restrained by passing the tiedown device over the cargo and attaching it to predetermined tiedown fittings in the cargo floor (Fig. 2—3). The tiedown device generally should be as short as possible and follow as closely as possible the contour of the cargo it is securing to minimize slippage. When tiedown devices are passed over cargo in the forward and aft direction, the tiedown device should be as close to 90 degrees as the floor fitting will permit. However, the tiedown angle of any additional devices on the aft side of the cargo should be as near 45 degrees as possible, to obtain added restraint against any tendency the cargo may have to tumble forward. This procedure is particularly important when tying down tall items and composite cargo loads consisting of several boxes stacked on top of each other. In arranging composite loads, cargo should not be stacked so that it will be top-heavy (Fig. 2—4). The height of a composite load should not be greater than its length in the longitudinal direction. When the cargo to be transported consists of more than one item, it may be possible to restrain it by the use of a cargo net or nets (Figs. 2—5 and 2—6). Exercise caution when using nets to secure nonpalletized composite loads, since concentrated loads may crush lighter cargo against the net or against other cargo. Concentrated units must be attached to the cargo floor with tiedown devices. Lighter cargo can be placed around them and the net placed over the complete load.



NOTE:
STRAP X HOLDS STRAP Y IN THE DESIRED POSITION.

FIGURE 2–3. TIEDOWN ANGLES FOR CARGO WITHOUT TIEDOWN PROVISIONS

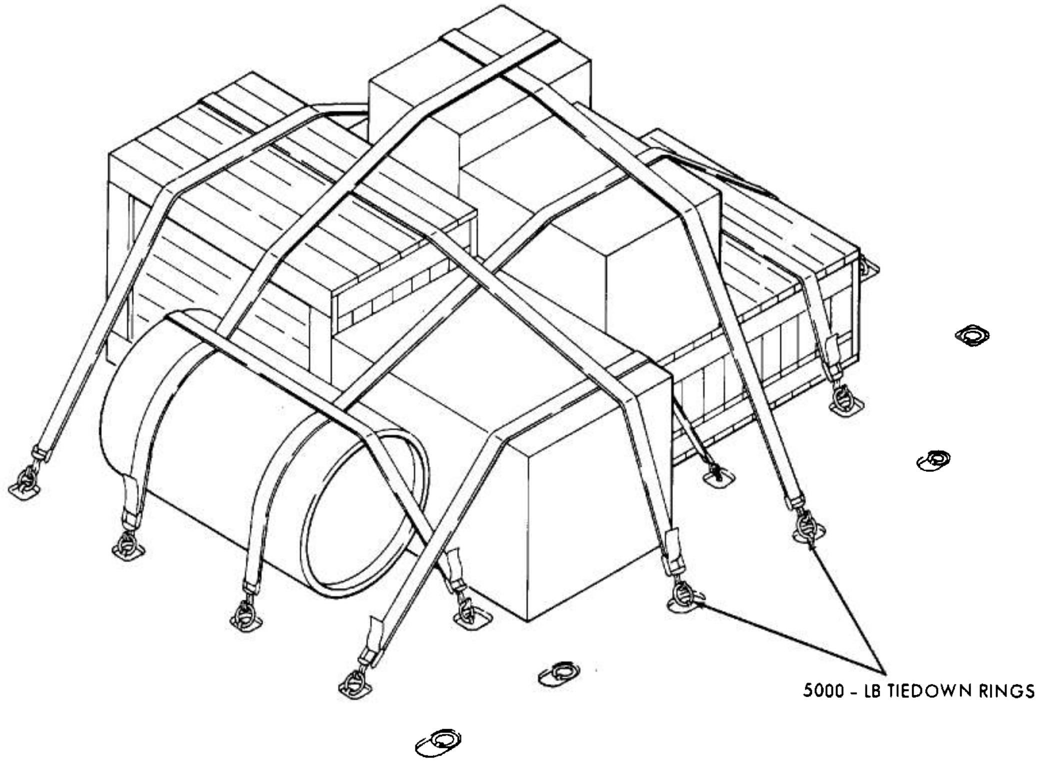
2—3.3 UNCRATED CARGO. Figure 2—7 shows the method of tying down various types of long, uncrated, slender cargo items such as pipe, bar stock, construction steel, and I-beams.

2-3.4 CYLINDRICAL CARGO. Figure 2-8 illustrates the method of tying down cylindrical cargo items.

2—4 SHORING

Shoring is lumber, planking, or similar material used for weight spreading, load support, and protection of aircraft floors.

2—4.1 WEIGHT SPREADING EFFECT. In general, shoring will increase the area over which a load is distributed to the area developed by extending a line, drawn downward and outward from the outside line of contact of the load, at an angle of 45 degrees, until it intersects the surface on which the shoring rests (Fig. 2—9)[33].



NOTE:
WHEN A STRIP IS TIED BETWEEN TWO FITTINGS OF UNEQUAL STRENGTH, THE RESTRAINT OBTAINED IS THE STRENGTH OF THE WEAKER FITTING.

FIGURE 2-4. TYPICAL COMPOSITE LOAD SECURED WITH TIEDOWN DEVICES

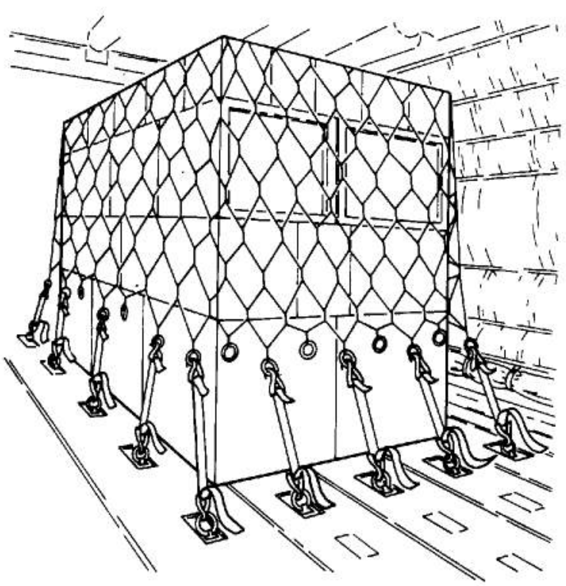
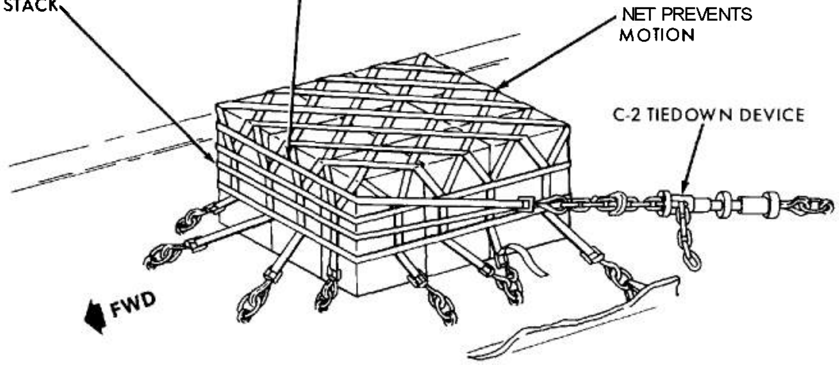


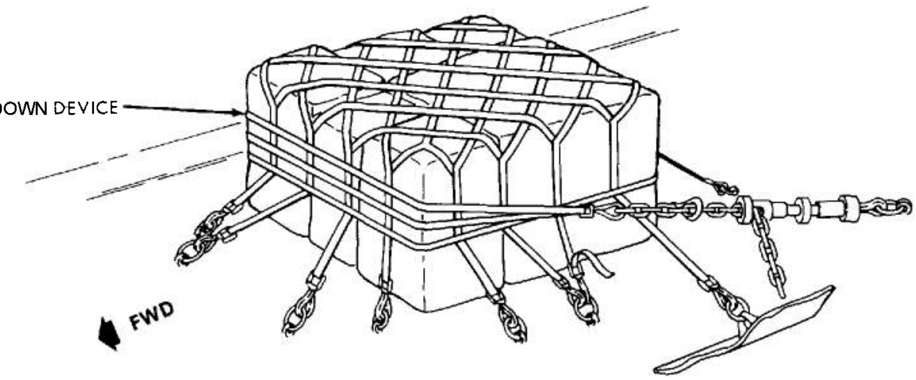
FIGURE 2-5. CARGO SECURED WITH A-2 CARGO NET

2-4.2 NEED FOR SHORING. In determining the need for shoring for a given load, only the area of contact with the floor is considered. In calculating the contact area for rectangular-shaped loads, the width of the item is multiplied by the length. As an example of load spreading, in Fig. 2-9, assume that the plank is 2 inches thick, and the box is 12 inches long by 6 inches wide. The area of contact between the box and the plank will be 72 square inches. Now extend imaginary planes downward and outward from the edges of the bottom of the box at angles of 45 degrees. Where these imaginary planes intersect the cargo floor, the area of contact will be 10 by 16 inches, or 160 square inches. In this case, the area of contact has been more than doubled, or an increase of 122 percent, but the proportioned increase will not always be so great. When 2-inch thick shoring is used, the area



NOTE:
WHEN CARGO IS STACKED CLOSE TO FUSELAGE WALL, PRE-POSITION CARGO NET AND SECURE TO FUSELAGE WALL AS SHOWN. AFTER CARGO IS STACKED, SECURE NET.

BOXED CARGO

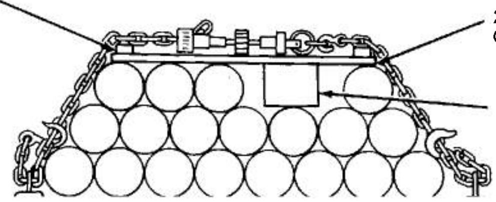


SACKED CARGO

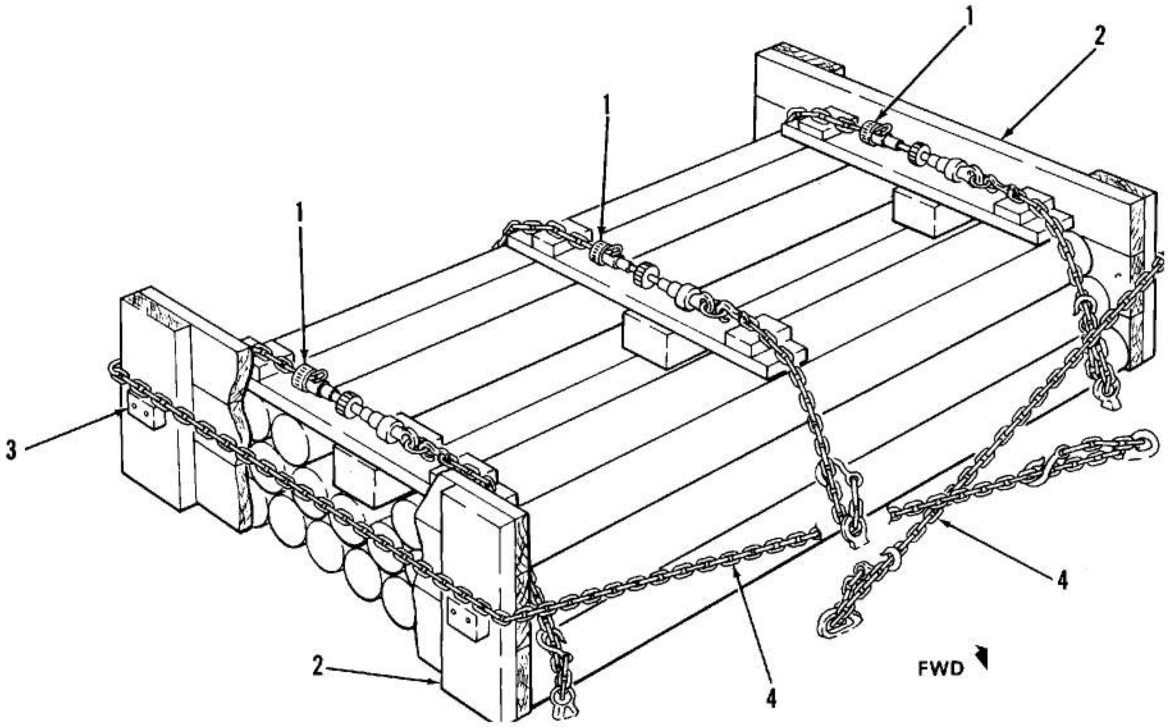
1 STACK CARGO IN TIEDOWN POSITION.
2 UNFOLD MA-2 OR MA-3 CARGO NET AND ATTACH FIXED STRAPS TO TIEDOWN RINGS.
3 ADJUST POSITION OF NET TO REMOVE SLACK FROM FIXED STRAPS AND FOLD CORNERS SNUGLY AROUND STACK.
4 ATTACH ADJUSTABLE STRAPS TO TIEDOWN FITTINGS AND TIGHTEN TO SECURE CARGO.
5 PROVIDE FORWARD RESTRAINT WITH C-2 AND MC-I TIEDOWN DEVICES AS SHOWN.
6 TO RELEASE NET, REVERSE ATTACHMENT PROCEDURE.

FIGURE 2-6. CARGO SECURED WITH MA-2 AND MA-3 CARGO NETS

over which the load is distributed is enlarged by a border 2 inches wide all around the area of contact of the load and the shoring. This border is as wide as the shoring is thick. Thus, if the shoring is 1 inch thick, the load bearing border added is 1 inch wide. If it is 3 inches thick, the load bearing border added is 3 inches wide, etc. However, as a general rule, the use of shoring more than 4 inches thick is not practical. The relation between the width of the border and the thickness of the shoring is applicable to all shoring. Since the increase in area occurs only around the perimeter of the area of contact of the load with the shoring, the larger the area of contact, the smaller is the proportional increase in contact area. Example: Shoring 2 inches thick under a box 12 inches square will increase the area of contact 77 percent



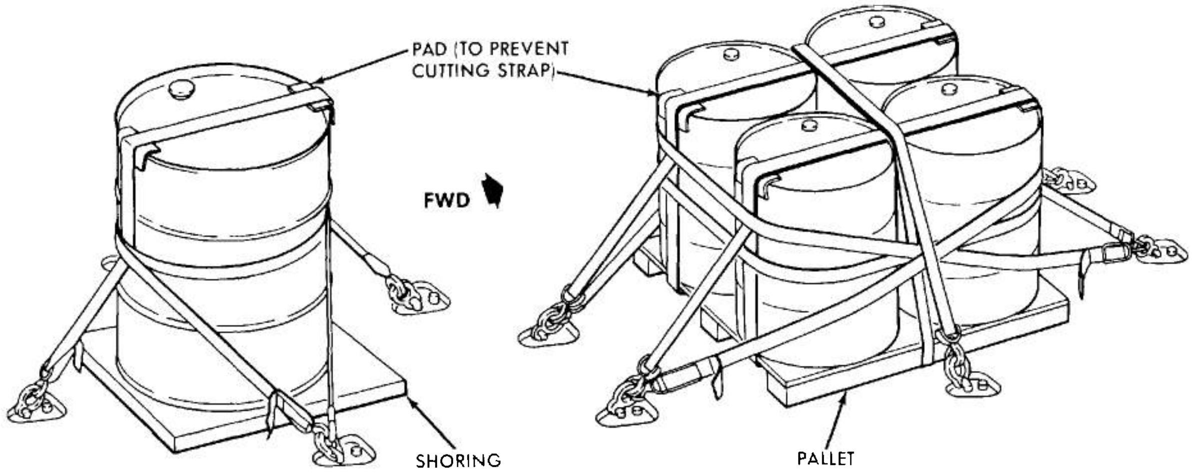
WEIGHT 12,000 LB



NOTE:
ALTHOUGH MORE TIEDOWN DEVICES MAY BE REQUIRED FOR THE RESTRAINT OF HEAVIER STACKS OF UNCRATED STOCK MATERIAL, TIE-DOWN METHODS SHOULD FOLLOW THE SAME BASIC PATTERN AS SHOWN.

1. 25,000-LB D-1 TIEDOWN DEVICE, ANCHORED TO 25,000- OR 35,000-LB TIEDOWN FITTINGS, KEEPS CARGO FROM MOVING UP AND SIDEWARD. (CHAIN PROVIDES 50,000-LB RESTRAINT IN SIDE DIRECTION AT 60 DEG RELATIVE TO FLOOR.)
2. RESTRAINT BULKHEADS MADE OF 2- x 12-IN. PLANKS MUST BE INSTALLED FWD AND AFT OF ALL ITEMS OF CARGO NOTED TO KEEP THEM FROM MOVING FWD OR AFT.
3. CLEAT TO HOLD TIEDOWN DEVICE UP.
4. 25,000-LB D-1 TIEDOWN DEVICE, ANCHORED TO 25,000- OR 35,000-LB TIEDOWN FITTING ON EITHER SIDE OF CARGO, KEEPS CARGO FROM MOVING FWD OR AFT. (CHAIN PROVIDES 37,000-LB MINIMUM FWD RESTRAINT IF ANGLE OF CHAIN IS LESS THAN 30 DEG RELATIVE TO LONGITUDINAL AXIS.]

FIGURE 2–7. TIEDOWN OF LONG SLENDER CARGO



NOTE:
LARGE CYLINDRICAL OBJECTS MAY BE TIED DOWN WITH THE CYLINDRICAL SURFACE AGAINST THE FLOOR. HOWEVER, IT IS SAFER TO PLACE THE CYLINDERS ON END. THIS ENABLES FRICTION BETWEEN THE FLOOR AND THE FLAT ENDS OF THE CYLINDERS TO AID IN THEIR RESTRAINT. IF CYLINDERS HAVE PROTRUSIONS, USE SHORING OR PALLETIZE TO DISTRIBUTE THE LOAD.

FIGURE 2-8. TIEDOWN OF CYLINDRICAL CARGO

by adding **112** square inches to the original **144.** Shoring **2** inches thick under a box 60 inches square will increase the area of contact by only about **14** percent by adding **496** square inches to the original **3600** square inches. The spreading effect of simple shoring is the same regardless of the shape of the area of contact.

2—4.3 AREA CONTACT PRESSURE. To determine the area contact pressure of a load, divide the individual contact area into the weight of the load on that area. Once the weight per unit of measurement of the bearing surface of the load has been determined, the data can be used for comparison with the load limits of the aircraft floor. Example: **A** box **6** feet long **by** 10 feet wide by 7 feet high. has a bearing surface area of 60 square feet. If the box weight is 600 pounds, it would distribute its weight **at 10** pounds per square foot or 0.07 pounds per square inch.

2–5 TIEDOWN DEVICES

Most aircraft are equipped with appropriate strap or chain and tension assemblies (tiedown devices) for cargo restraint. Each tiedown is rated to withstand a specific load or force. However, the effective holding strength of a device is determined by the rated strength of the device and the manner in which it is employed. All tiedown devices must be anchored to a tiedown fitting. The strongest tiedown is no stronger than the fitting to which it is attached. Types of tiedown devices used for securing cargo and their characteristics are described below.

2—5.1 A-2 *(9* BY *9* FEET) CARGO NET. Miscellaneous general cargo items of light weight and varying shapes, that do not have attachment points to which tiedown hooks can be applied, can be effectively and conveniently tied down with **A-2** cargo nets (Fig. 2—5). These steel cable nets are often used to cover cargo secured by other types of tiedowns, to prevent small items of cargo from being scattered. The net has guarded metal hooks spaced 20 inches apart along two adjacent sides. The other two sides are fitted with metal rings similarly spaced. Methods of securing the net vary somewhat

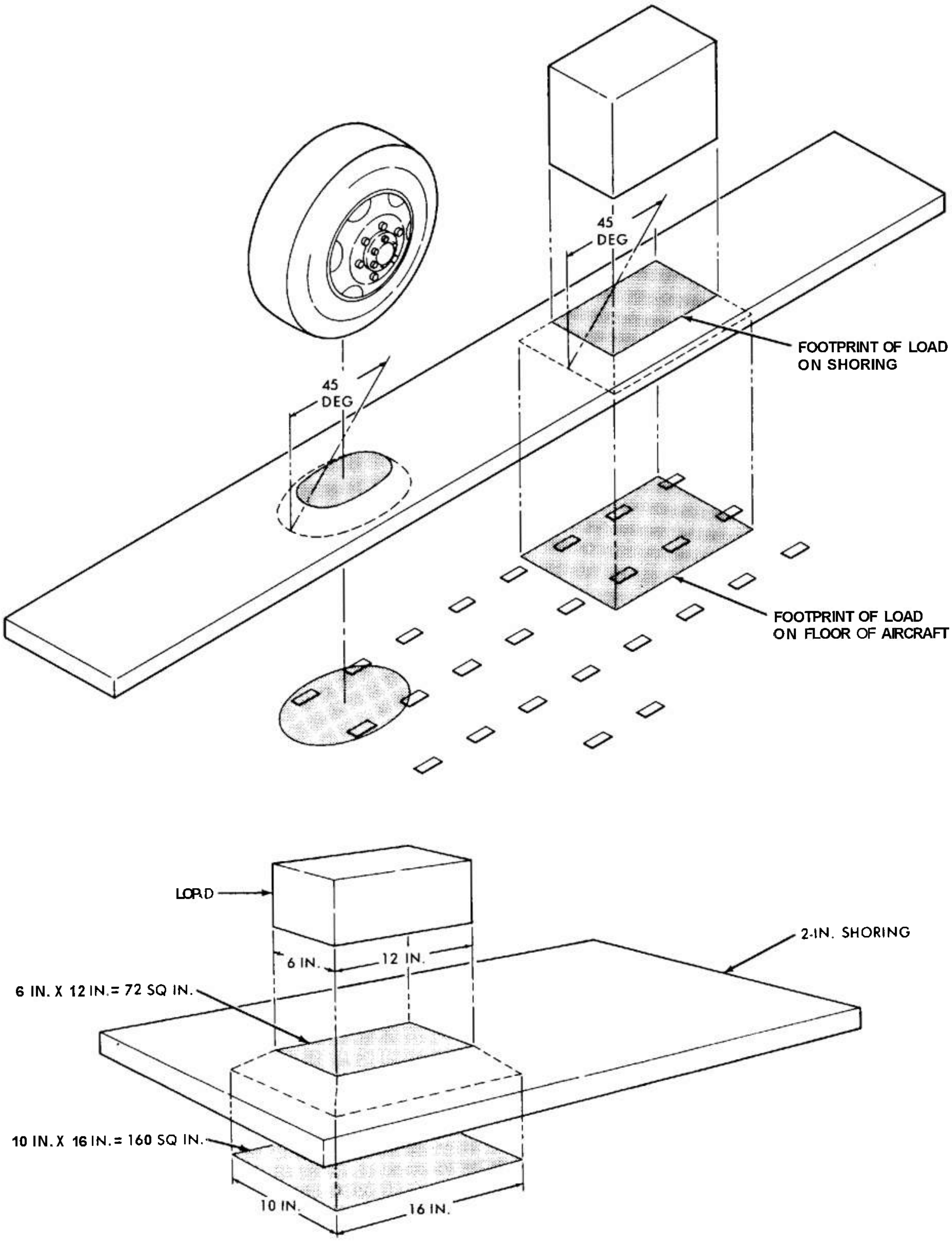


FIGURE 2-9. WEIGHT SPREADING EFFECT OF SHORING

depending on the size and shape of the cargo. In most cases, it is convenient to attach the hooks in one end to a lateral row of tiedown rings and then attach the hooks along an adjacent side to a longitudinal row. With two sides thus attached, the opposite sides can be pulled tight with A-1A tiedown devices (par. 2—5.11) or threaded with C-2 tiedown devices (par. 2—5.9). A-1A tiedown devices may be hooked to the mesh of the net if necessary to take up excess slack; however, when C-2 tiedown devices are used, they should be threaded only through the rings. The restraint capacity of the net depends on the number of hooks and rings used to secure it in place. When all rings and hooks on each side are used, the capacity is 10,000 pounds.

2—5.2 MA-2 (15 BY 15 FEET) AND MA-3 (15 BY 20 FEET) CARGO NETS. These nets (Fig. 2—6) are made of webbed nylon straps and have restraint capacity of 10,000 pounds each. Fixed straps approximately 10 inches long and equipped with snap hooks are attached to one side of the nets. The remaining sides of the nets are equipped with adjustable straps approximately 4 feet long. The adjustable straps are also equipped with snap hooks. The nets may be used to restrain stacks of general cargo, such as boxes, sacks, metal containers, or a combination of miscellaneous items.

2—5.3 MB-1 TIEDOWN DEVICE. The MB-1 tiedown device (Fig. 2—10), Military Specification MIL-T-25959A, has a rated strength of 10,000 pounds and consists of a 9-foot steel chain with an L-shaped hook attached to one end. The other end of the chain passes through a snap fastener hook device which locks the chain when in tension. A quick release lever on the device makes it possible to detach the two components instantly, regardless of the tension on the chain. A tensioning grip, in the form of a knurled ring on the device, allows final tensioning of the chain to be carried out. In use, the L-shaped hook end of the chain is passed over and around part of the load, and the hook is then engaged with a link of the chain. The hook of the device is then

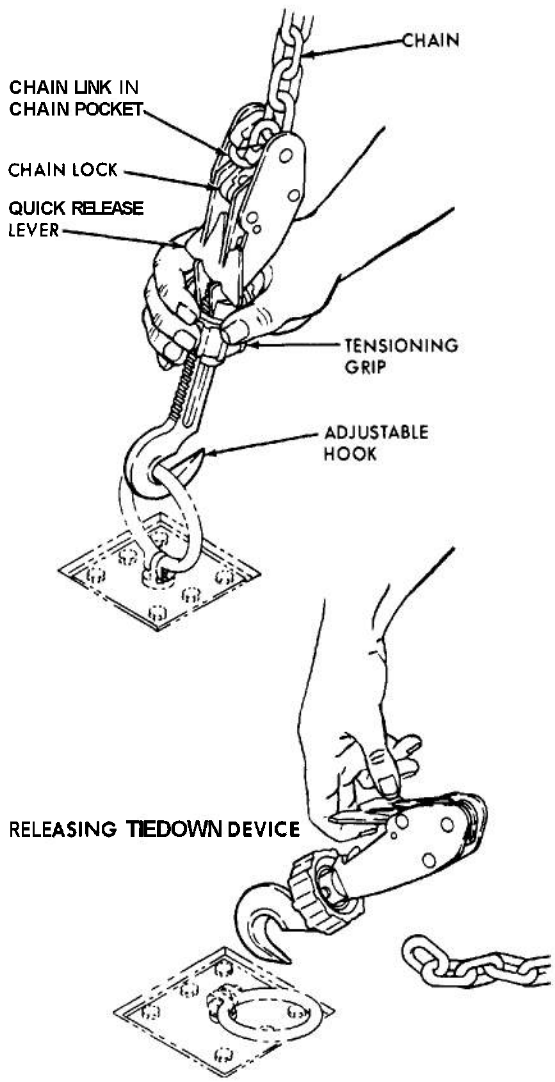


FIGURE 2-10. MB-1 TIEDOWN DEVICE

engaged to a tiedown ring, as shown in Fig. 2—10.

2—5.4 MB-2 TIEDOWN DEVICE. The MB-2 tiedown device, Military Specification MIL-T-25960A, has a rated strength of 25,000 pounds. It is similar in construction and operation to the MB-1 tiedown device described in par. 2—5.3.

2—5.5 MC-1 TIEDOWN DEVICE. The MC-1 tiedown device (Fig. 2—11) has a rated strength of 5000 pounds and consists of a 15-foot web strap with a fixed snap hook on one end of the strap and a latch with a

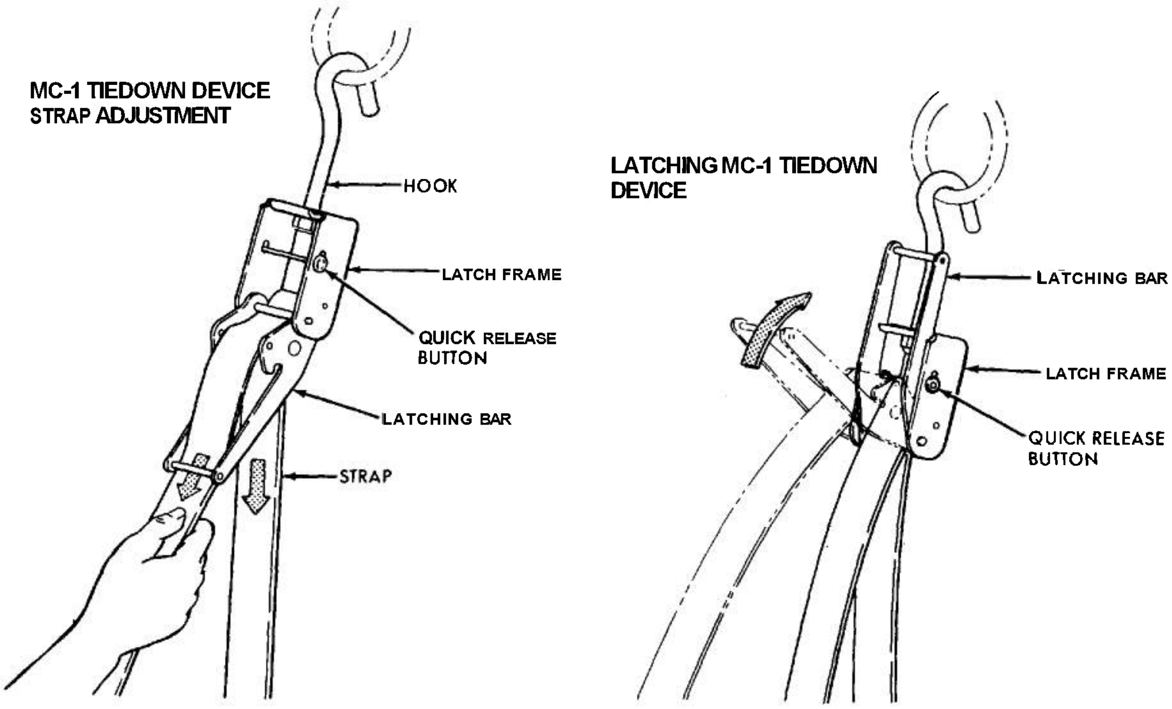


FIGURE 2–11. MC-1 TIEDOWN DEVICE

movable hook on the other. In use, the fixed hook is secured to one of the aircraft tiedown fittings while the movable hook is secured to the cargo item. If the cargo item does not have an attaching point, then the strap is passed over or around the cargo and the movable hook is secured to another aircraft tiedown fitting. The strap is tightened by pulling its free end through the latch frame and latching bar. Final tensioning is made by closing the latching bar, which engages with a spring-loaded retainer bar. To remove the device, actuate the quick release button, which will release the latching bar.

2–5.6 CGU-1/B TIEDOWN DEVICE. The CGU-1/B tiedown device (Fig. 2—12), Military Specification MILT-27260, is similar to the MC-1 tiedown device described in par. 2—5.5. It is an improvement over the MC-1 and will eventually replace it. It has a rated strength of 5000 pounds and consists of a web nylon strap approximately 20 feet long with a fixed snap hook on one end and a movable hook on the other. The movable hook end of this device, unlike the MC-1, has a ratchet system for applying tension to the device.

2–5.7 MC-2 TIEDOWN DEVICE (CHAIN RIDER). The MC-2 tiedown device (Fig. 2—13) is a chain assembly having a rated strength of 10,000 pounds, designed for use with the MC-1 tiedown device. The MC-1 tiedown device must form a complete loop around a portion of the cargo and the roller of the chain assembly to provide a 10,000-pound capacity for this combination. The assembly is used to tie down intermediate-weight cargo. It hooks to itself or to a tiedown fitting and attaches to an MC-1 tiedown device. The chain rider consists of a short length of chain which has an open hook at one end and a fastening device (strap bracket) at the other, which permits installing the chain rider on the MC-1 tiedown device. It is used to secure rough-edged items that might cut or scuff the nylon strap.

2–5.8 B-1A TIEDOWN DEVICE. The B-1A tiedown device (Fig. 2—14) has a rated strength of 5000 pounds. It consists of a length of cable with a snap fastener hook

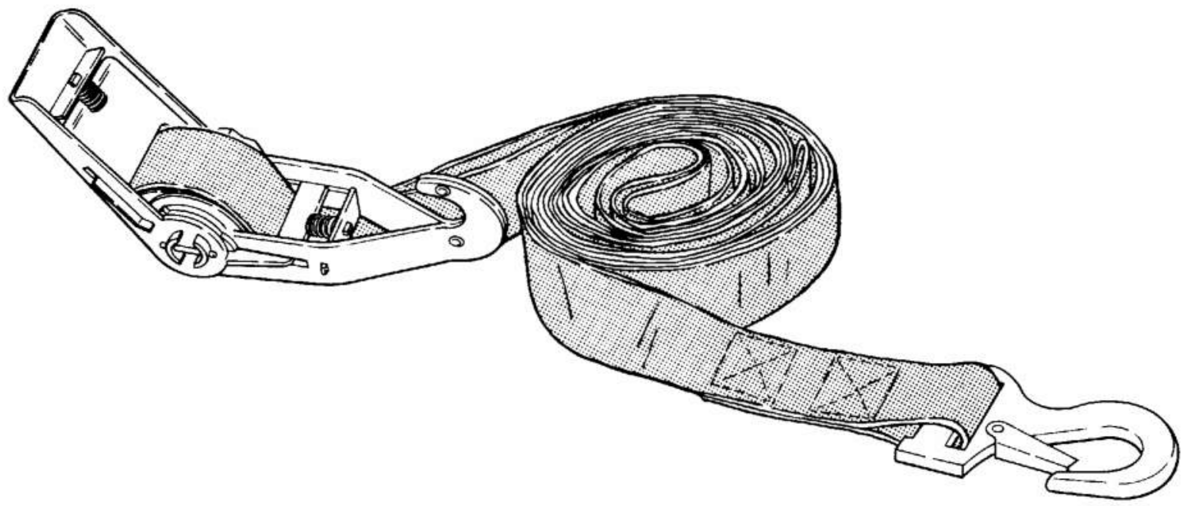


FIGURE 2-12. CGU-1/B TIEDOWN DEVICE

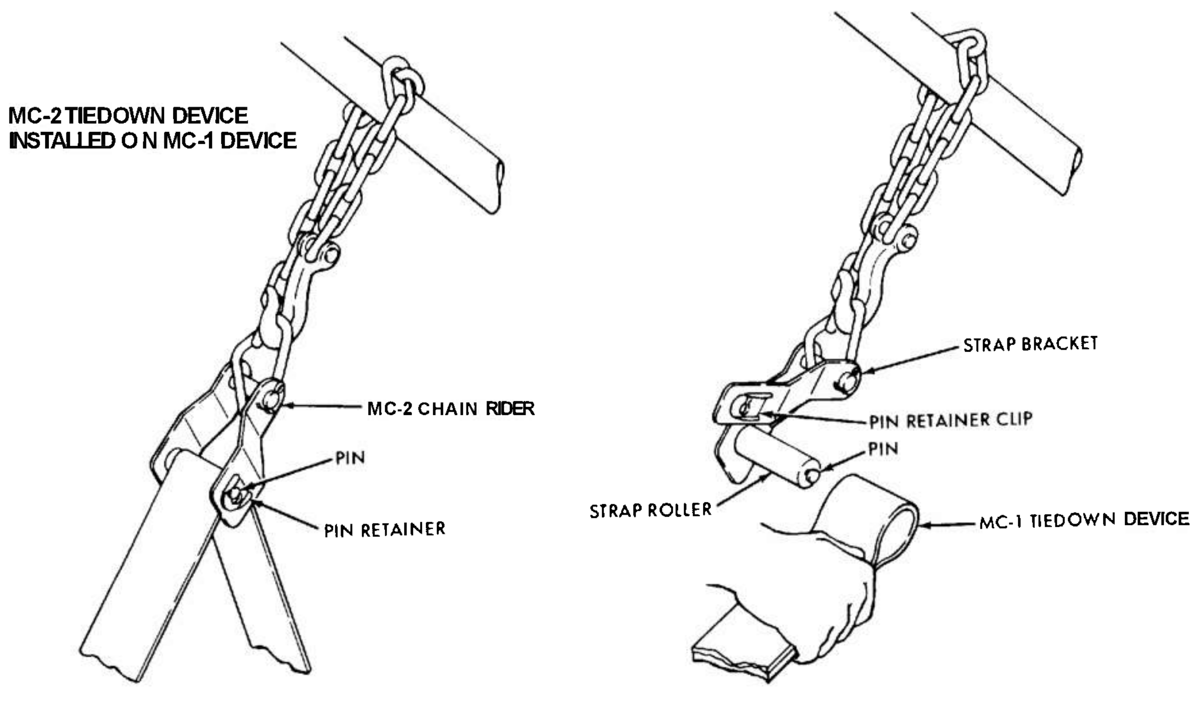


FIGURE 2-13. MC-2 TIEDOWN DEVICE

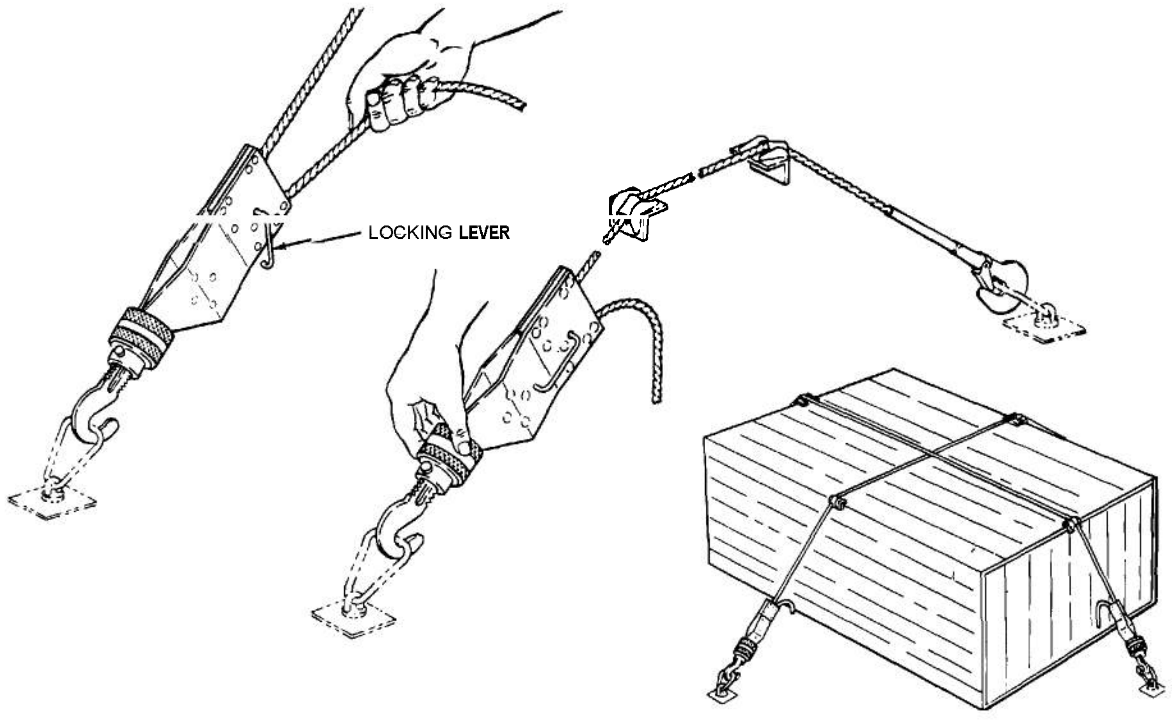


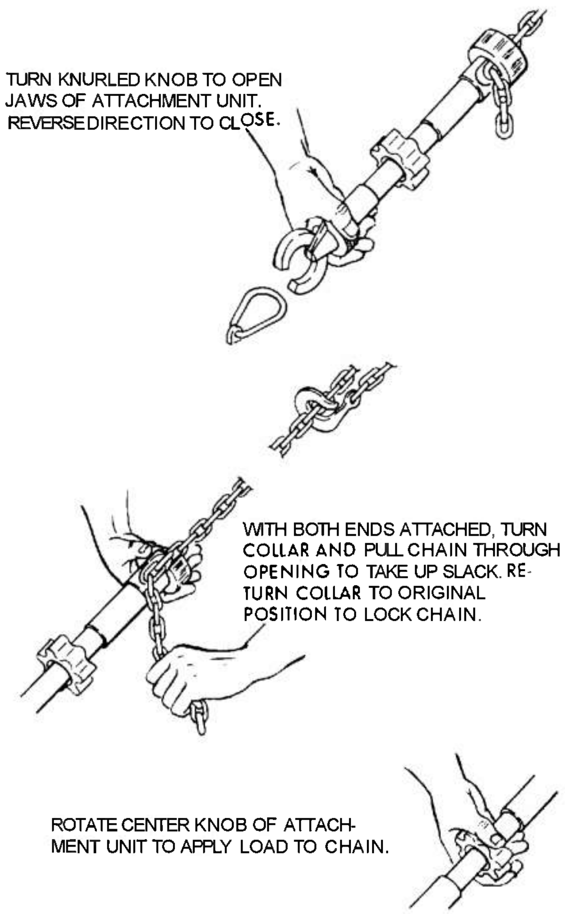
FIGURE 2-14. B-1A TIEDOWN DEVICE

on one end and a quick release and tensioning device on the other. Two angle irons run free on the cable to prevent it from fraying when it passes over sharp edges. The quick release assembly has an open hook, an adjusting nut, a locking lever, and a series of pulleys. The cable is approximately **16** feet long and **7/32** inch in diameter.

2—5.9 C-2 TIEDOWN DEVICE. The C-2 tiedown device (Fig. **2—15)** has a rated capacity of 10,000 pounds. The tiedown assembly is composed of a special steel chain, attachment fittings, and a mechanism incorporating provisions for adjustment, tensioning, locking, **and** releasing the chain. On one end of the device, a slotted adapter is used for gripping the chain. A set of quick release jaws serves for attaching the assembly to the floor tiedown rings. The other end of the chain, equipped with an L-shaped hook, can be used for forming loops around the attaching points on cargo. The chain is 108 inches long and is made from **9/32**-inch forged links. The **C-2** tiedown device should not be used on items to be air-dropped.

2—5.10 D-1 TIEDOWN DEVICE. The D-1 tiedown device **(Fig. 2—15)** has a rated capacity of **25,000** pounds. It is similar in construction and operation to the **C-2** tiedown device described in par. **2—5.9,** differing only in size and tensile strength.

2—5.11 A-1A TIEDOWN DEVICE. The A-1A tiedown device (Fig. **2—16),** Military Specification MIL-T-7181, has a rated capacity of **1250** pounds and consists of a 15-foot webbed strap with a fixed snap hook on one end and a movable hook on the other. When in use, the fixed snap hook is attached to a tiedown fitting or to the item of cargo which is being **secured.** The **device** is then passed over or around the cargo to another fitting where the movable hook is attached. The strap is then tightened by pulling the free end through the movable hook. To remove the device, tension on the strap is released by depressing a thumb plate between the sides of the movable hook.



NOTE:
C-2 TIEDOWN DEVICE SHOWN. D-1 TIEDOWN DEVICE DIFFERS ONLY IN SIZE AND TENSILE STRENGTH.

FIGURE 2-15. C-2 AND D-1 TIEDOWN DEVICES

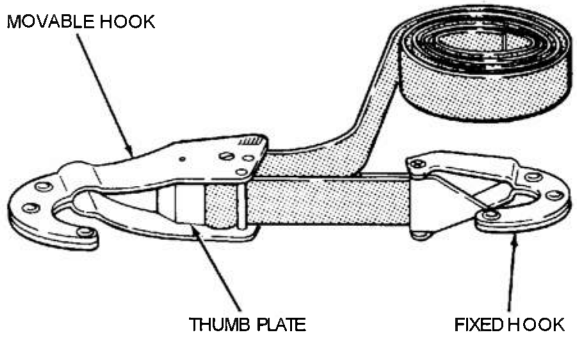


FIGURE 2-16. A-1A TIEDOWN DEVICE

SECTION II

PALLET LOADING AND RAIL SYSTEMS

2–6 PALLETS

There are three standard 463L cargo pallets used to facilitate the transportation of cargo in aircraft and within freight terminals—HCU-6/E (Fig. 2—17), HCU-10/C (Fig. 2—18), and HCU-12/E (Fig. 2—19). These military pallets are of bonded sandwich construction. The bottom surface is a continuous sheet of 0.080 ± 0.003 inch -7075 aluminum. The top surface is a continuous sheet of 0.063 ± 0.003 inch -6061-T6 aluminum. Top and bottom surfaces are fastened to the edge extrusions with rivets. The core material between the metal outer surfaces is of end grain balsa wood with a density of 6 to 9 pounds per cubic foot. A lip is provided on the periphery of the pallets to permit mating with aircraft rail systems. Tiedown rings are symmetrically located around the perimeter of the pallets to permit securing specially designed cargo tiedown nets. Each tiedown ring is capable of sustaining a 7500-pound tension load and has a free movement of 240 degrees in a vertical plane that intersects the pallet edge at right angles. A hoist or forklift may be used to lift the pallets. The load capacity and number of tiedown rings for each pallet are as follows:

PALLET	MILITARY SPECIFICATION	LOAD CAPACITY (lb)	NUMBER OF TIEDOWN RINGS
HCU-6/E	MIL-P-27443D	10,000	22
HCU-10/C	MIL-P-27648C	5,000	16
HCU-12/E	MIL-P-27700A	5,000	16

Commercial aircraft may utilize cargo containers (igloos) attached to pallets. These containers are shaped to fit the contour of the particular aircraft. A net surrounds the container to provide restraint against cargo movement. Advantages of igloos are reduction in damage to the passenger interior and more efficient loading of cargo.

2–7 METHOD OF SECURING

2–7.1 LOAD TO PALLET. Cargo tiedown nets are used to secure cargo loads to 463L cargo pallets. The nets are constructed of woven nylon webbing with metal attachments, and provide sufficient strength to meet the restraint criteria of transport aircraft. Each type of net is designed to be used with a particular cargo pallet. The HCU-7/E (Fig. 2—20) and HCU-15/C (Fig. 2—21) cargo tiedown nets, Military Specifications MIL-N-27444B and MIL-N-38255, respectively, are used with the HCU-6/E cargo pallets (Fig. 2—17). The HCU-11/C (Fig. 2—22) and HCU-16/C (Fig. 2—23) cargo tiedown nets, Military Specifications MIL-N-27647A and MIL-N-38256, respectively, are used with the HCU-10/C (Fig. 2—18) and HCU-12/E (Fig. 2—19) cargo pallets. Figure 2—24 illustrates use of a top net and a side net assembly — two side nets connected together at opposite corners — to properly secure a cargo load.

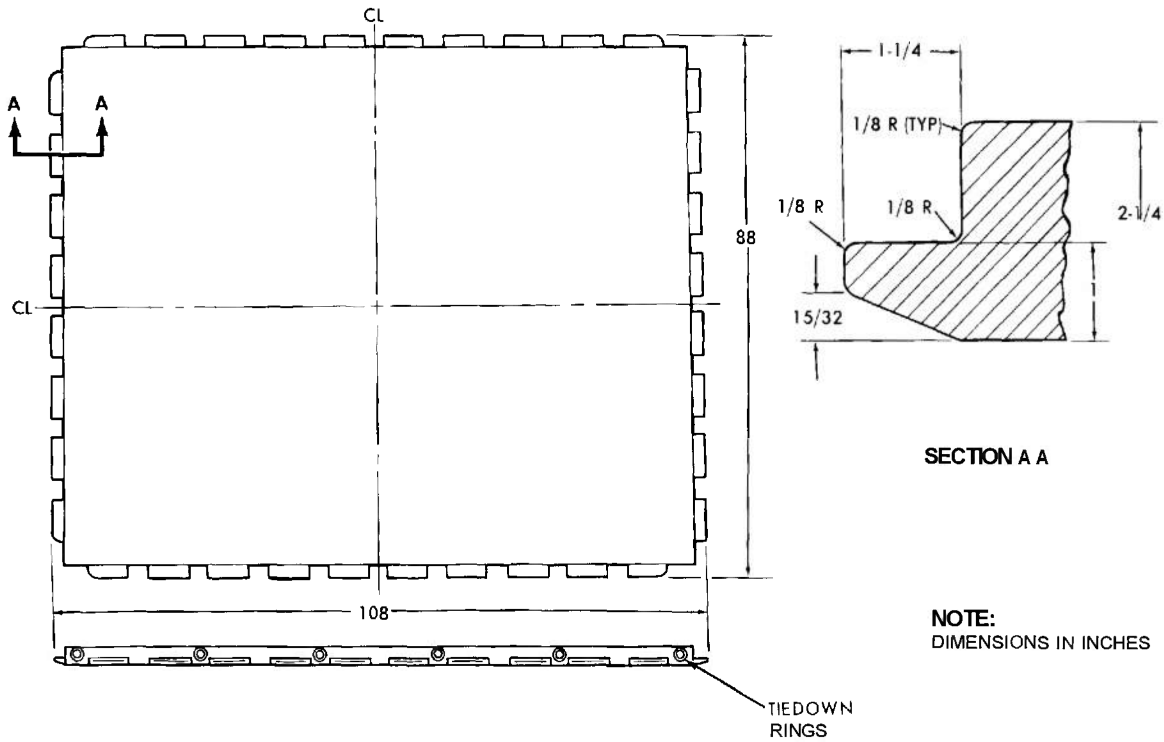


FIGURE 2-17. HCU-6/E CARGO PALLET

2-7.2 PALLET TO CARGO COMPARTMENT. The 463L cargo pallets are designed for compatibility with conveyorized rail restraint systems utilized in the CV-7A, C-130, and C-141 aircraft. The pallets are loaded into the cargo compartment on roller conveyors and positioned between two parallel restraint rails. The restraint rails prevent vertical and lateral movement of the pallets. Locking mechanisms located on the restraint rails are equipped with detents which, when in the locked position, engage the lip on the cargo pallet to prevent fore-and-aft movement. Pallets installed in the rail systems are restrained automatically to meet the applicable restraint criteria of the aircraft.

2-8 RAIL SYSTEMS

2-8.1 CONVEYORIZED RAIL RESTRAINT SYSTEM. The conveyorized rail restraint system (par. 3-11) provides aircraft with the capability to safely handle equipment and supplies for aerial delivery, and to expedite the handling of palletized cargo for terminal-to-terminal operations. The type of equipment and the operation of the system are essentially the same for both service applications. The conveyorized rail restraint system is employed in C-130, C-141, and CV-7A aircraft. The system used in the CV-7A aircraft is 88 inches wide and can carry the HCU-10/C and HCU-12/E cargo pallets. The system in the C-130 aircraft is adjustable to widths of 88 inches or 108 inches and can utilize the HCU-6/E, HCU-10/C, or HCU-12/E cargo pallets. The system used in the C-141 aircraft is 108 inches wide and is designed to carry the HCU-6/E cargo pallet.

2-8.2 CONVEYORS. Conveyors facilitate the loading of heavy or bulky, skid-mounted, palletized or containerized cargo[33]. Conveyors, Military Specification MIL-C-5927B, are assembled from sections of aluminum alloy conveyors, either 8 or 10 feet long and 1 foot wide (par. 3-9). Individual sections of conveyors may be coupled together end to end or side to side to form various combinations. These conveyors are organic

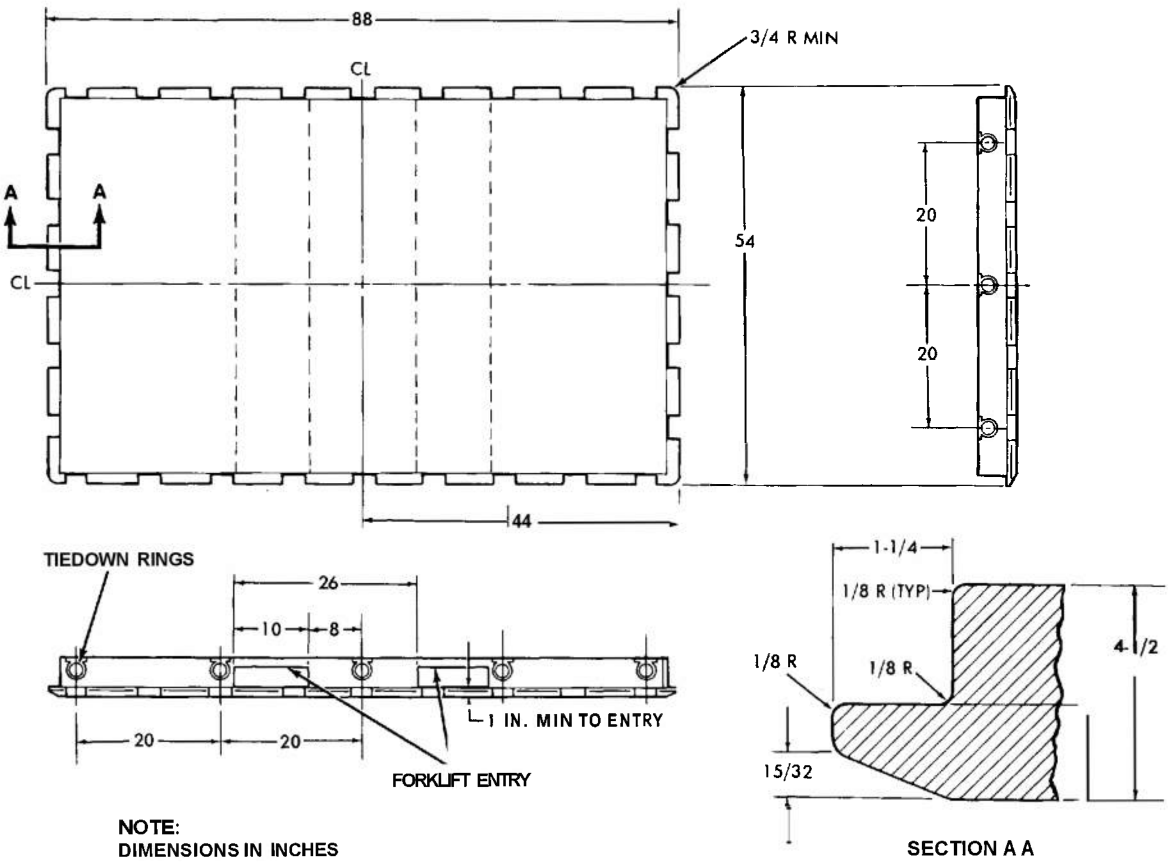


FIGURE 2–78. HCU-10/C CARGO PALLET

to some aircraft and as such are available, either installed or as onboard equipment. Typical installations of conveyors are shown in Figs. **3—17** and **3—18.** Twelve individual wheels, approximately **2** inches in diameter, are provided for each square foot of conveyor section area. The wheels permit longitudinal movement of pallets within the aircraft. Pallets placed on conveyors conforming to Military Specification **MIL-C-5927B** are secured to the aircraft floor with tiedown devices to provide the inflight restraint criteria.

The procedure for loading aircraft with conveyors installed in the cargo compartment is to off-load cargo directly from a transporting vehicle into the aircraft. The cargo and vehicle are prepared for the loading procedure as outlined in TM 55-450-93.

2—8.3 MONORAIL. An overhead monorail is installed in the **C-97** and **C-119** aircraft. A typical cross section of an overhead monorail, Military Specification **MIL-C-9153A,** is shown in Fig. **2—25.** The overhead monorail installed in the **C-119** is used **for air-**drop of **A-22** containers (par. **3—10).** Special aerial delivery equipment can be installed on the overhead monorail in the **C-97** aircraft; however, the Army does not utilize this aircraft for airdrop. The ***cargo*** hoist trolley, used for loading and unloading of cargo, travels the length of the cargo compartment on the **C-97** monorail.

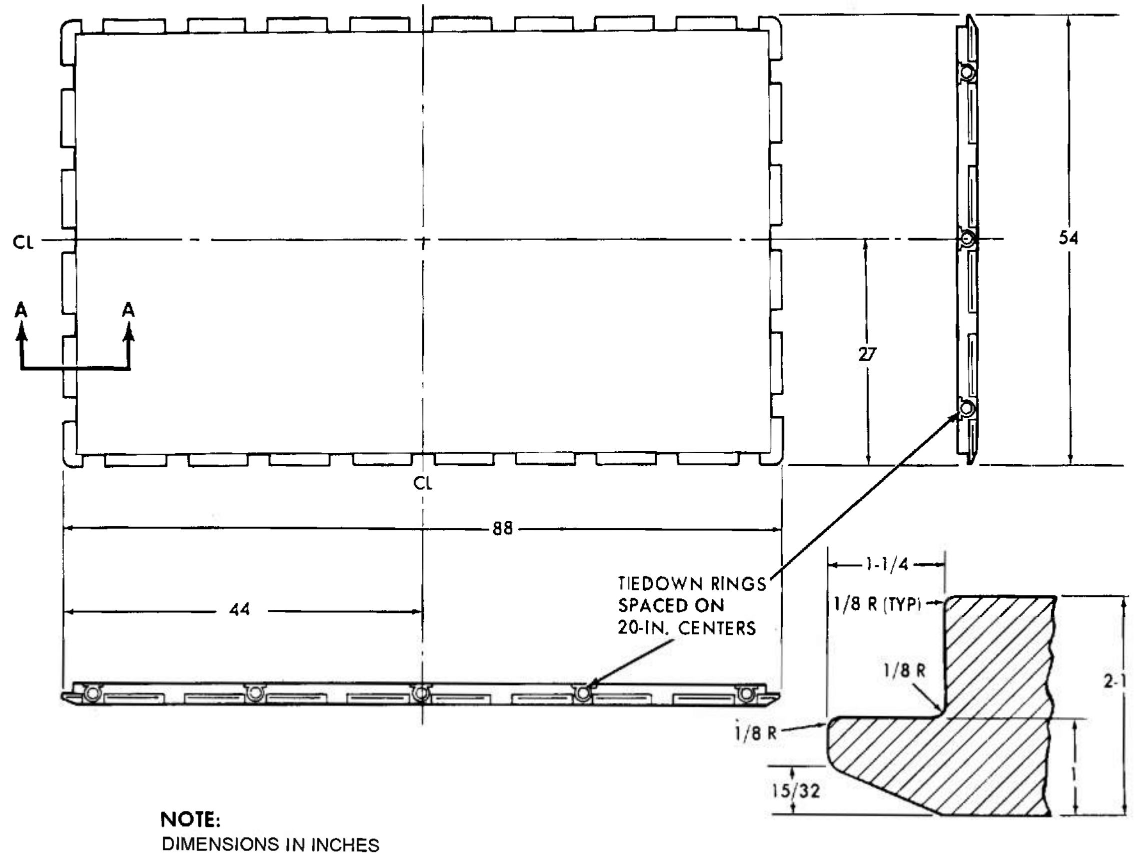


FIGURE 2-19. HCU-12/E CARGO PALLET

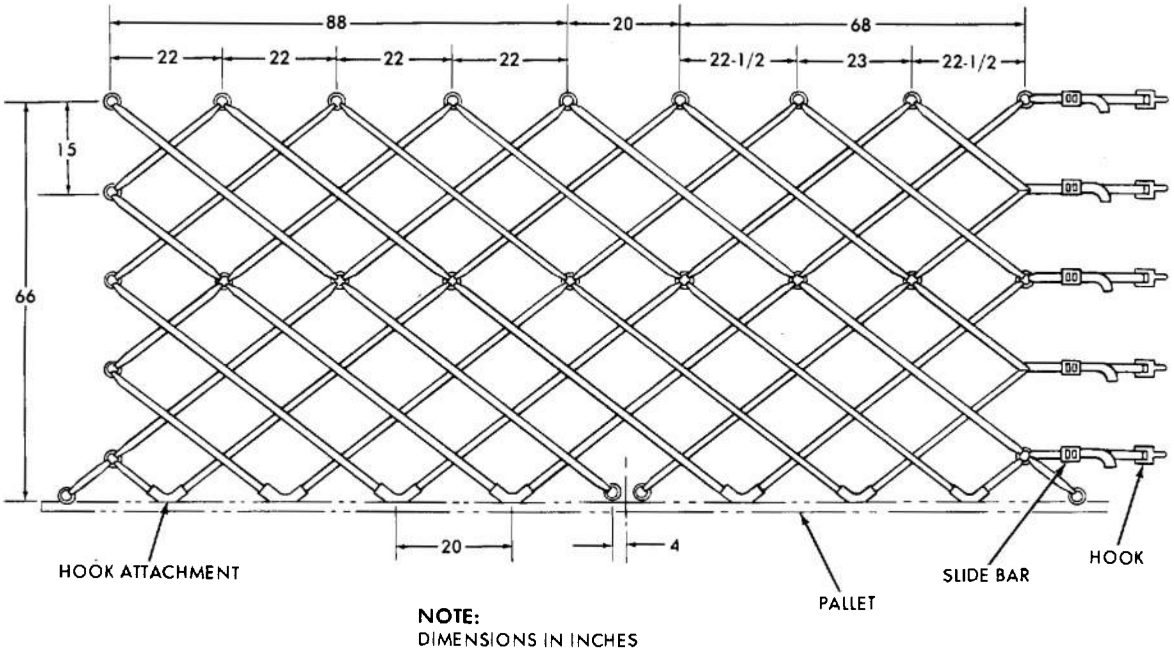
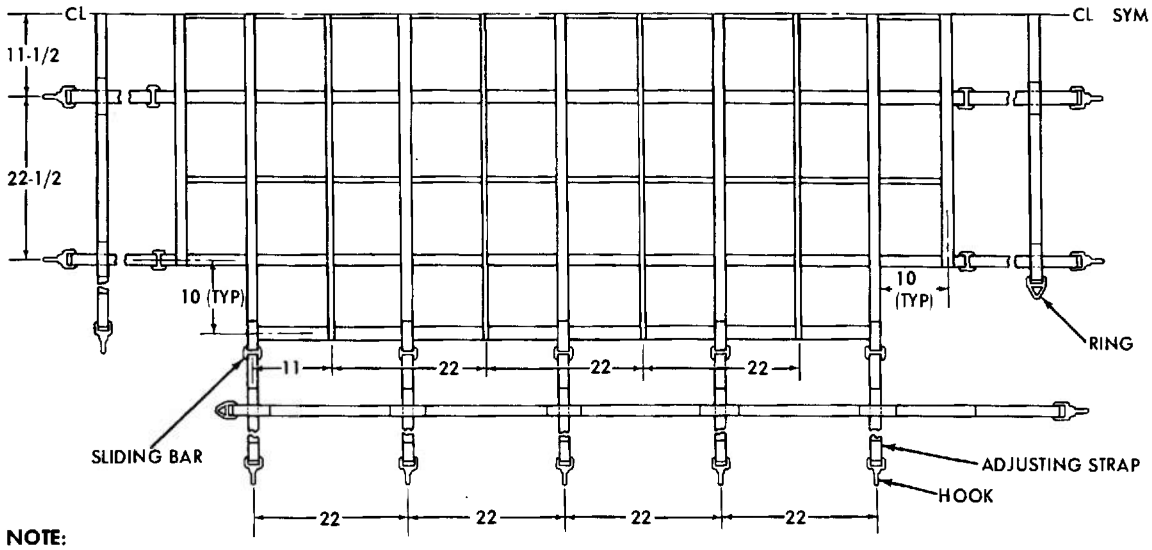
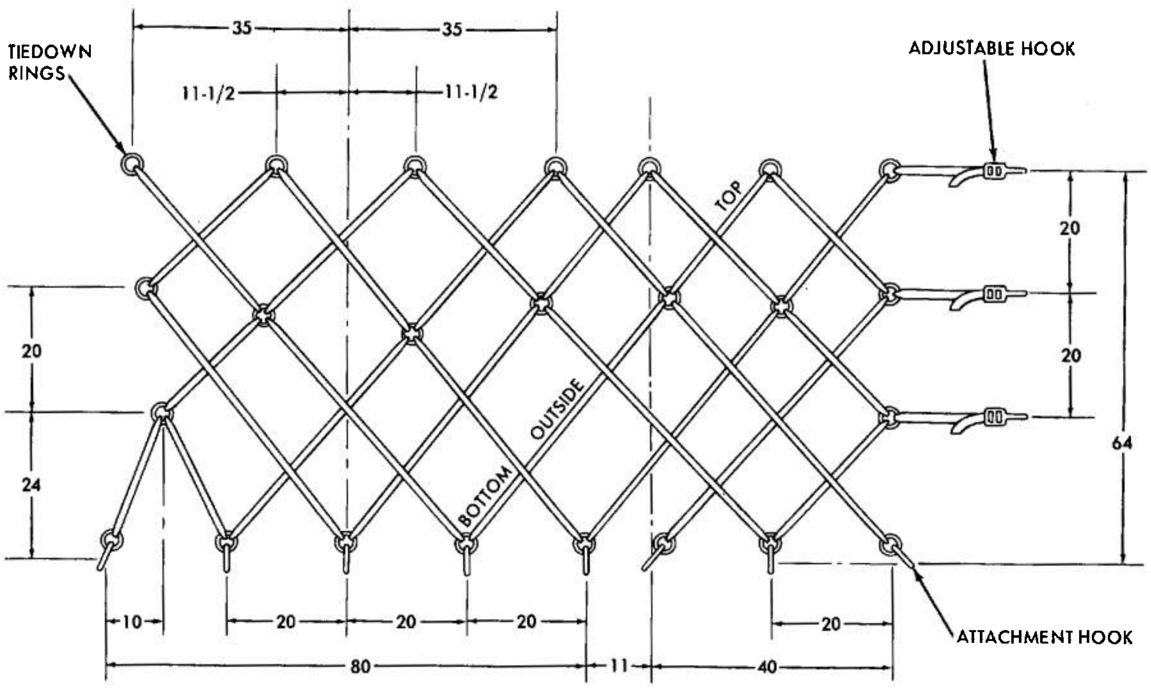


FIGURE 2-20. HCU-7/E CARGO TIEDOWN NET



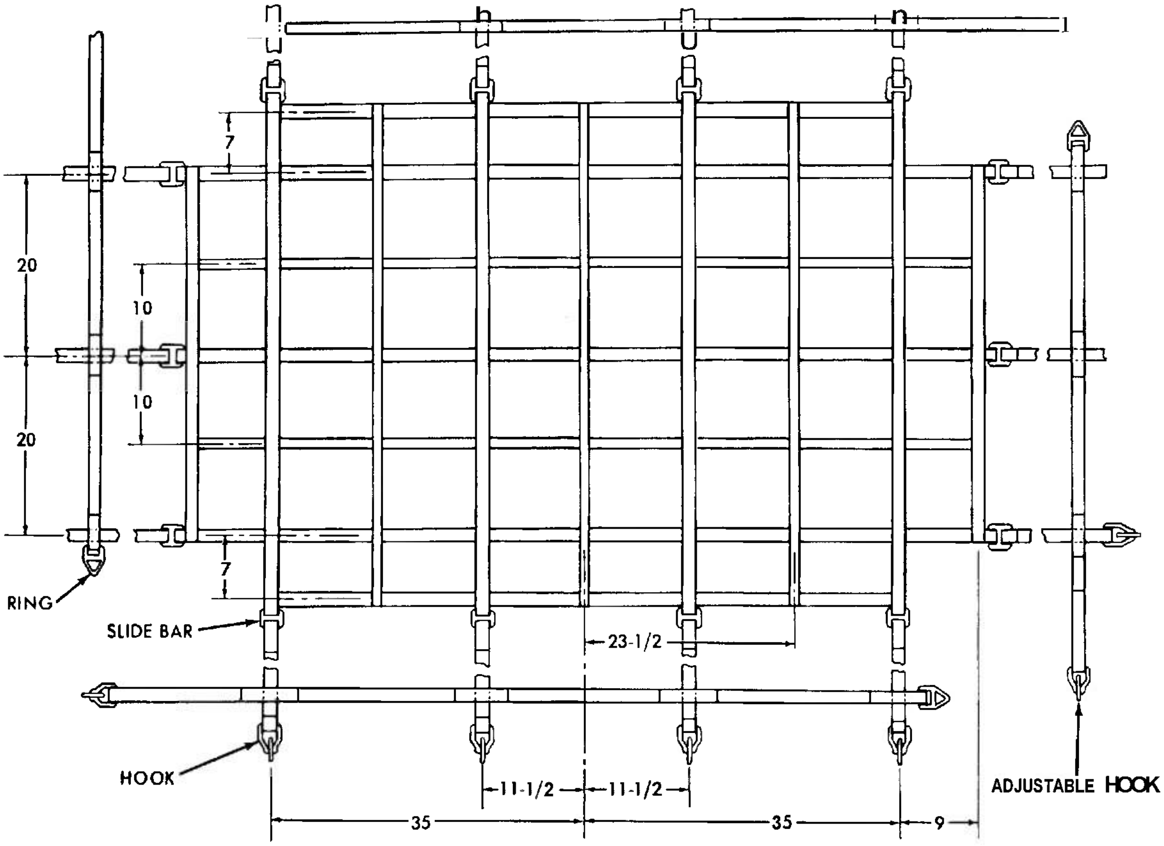
NOTE:
DIMENSIONS IN INCHES

FIGURE 2–21. HCU-15/C CARGO TIEDOWN NET (TOP VIEW)



NOTE:
DIMENSIONS IN INCHES

FIGURE 2–22. HCU-11/C CARGO TIEDOWN NET (SIDE VIEW)



NOTE:
DIMENSIONS IN INCHES

FIGURE 2-23. HCU-16/C CARGO TIEDOWN NET

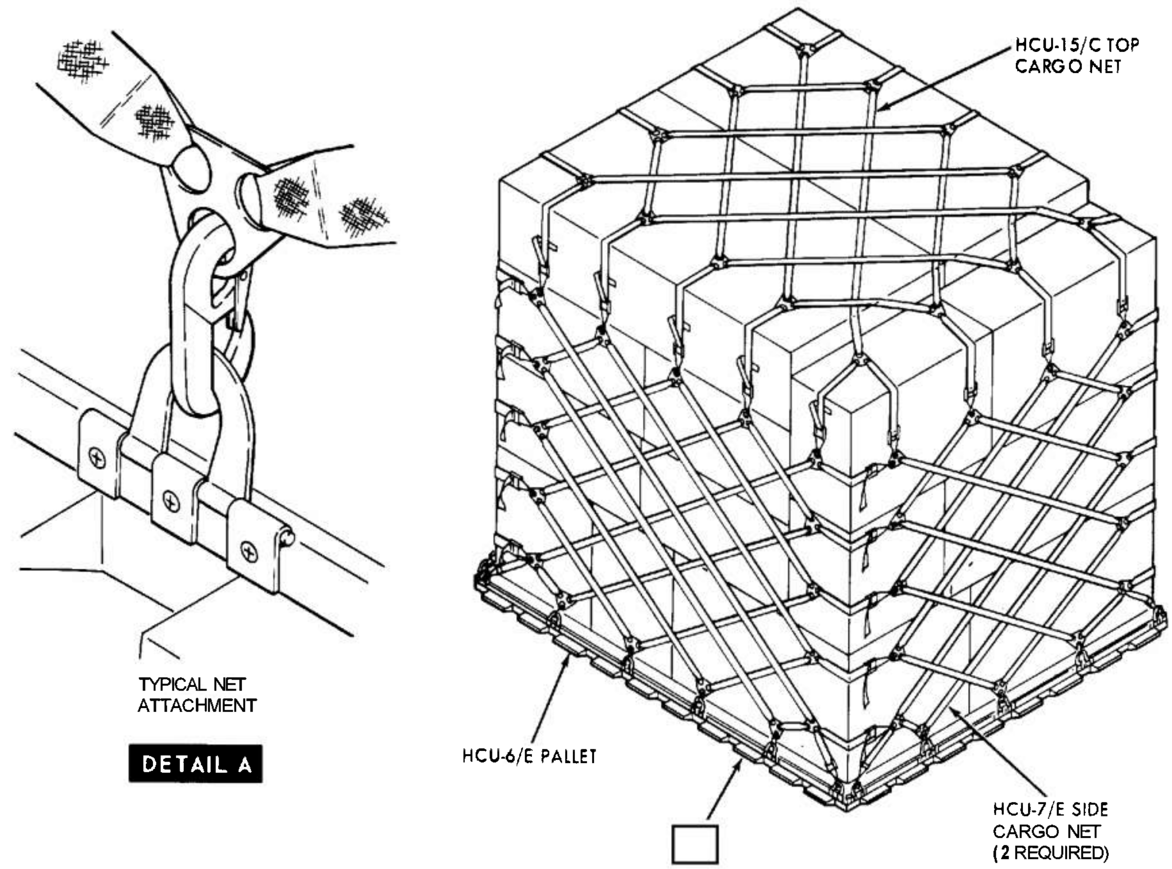


FIGURE 2-24. MISCELLANEOUS CARGO OR TROOP BAGGAGE TIEDOWN USING PALLET AND NET

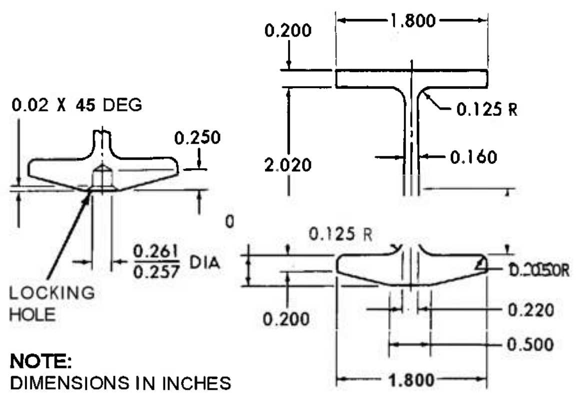


FIGURE 2-25, TYPICAL OVERHEAD MONORAIL CROSS SECTION

SECTION III

DESIGN CONSIDERATIONS FOR MATERIEL TO BE AIR TRANSPORTED

2–9 GENERAL

The Air Standardization Co-ordinating Committee (ASCC), composed of representatives of the United States, United Kingdom, and Canada, has published a general guide[1] for those who are concerned with the design of equipment which is required to be transported by, or airdropped from, transport aircraft belonging to the member nations. In addition, the Department of the Army has prescribed procedures for development of materiel to insure air portability and airdrop capability in Army and Air Force aircraft[2]. Explosives and other dangerous materials shall be packed, marked, and labeled, when offered for shipment by military aircraft, in accordance with procedures in TM 38-250[3].

2–9.1 DURABILITY, RELIABILITY, AND MAINTAINABILITY. The terms durability, reliability, and maintainability are familiar to most designers, and yet there exists a certain amount of confusion with respect to their distinction, particularly as used in airdrop equipment design. These terms are described, in general, in the following paragraphs.

Durability is the term used to describe the ability of an object, device, or system of devices to render satisfactory performance over an extended period of time of continual operation when used in the service for which it was intended. It deals with the operational endurance of the item and is related to the time period during which satisfactory performance is obtained.

Reliability is the interaction of the durabilities of the individual components that constitute a particular assembly and the probabilities that each of these components will perform satisfactorily for the intended period under the operating conditions encountered. Reliability also includes the capacity of the device to perform its mission after sustaining the destruction or failure of specific components.

Maintainability is a characteristic of design and installation which is expressed as the probability that an item will conform to specified conditions within a given period of time when maintenance action is performed in accordance with prescribed procedures and resources[4].

2–9.2 WEIGHT AND VOLUME. Items should be made as light and compact as possible, rather than merely capable of being airlifted. The weight and volume saved can be used for additional personnel, bulk supplies, and other equipment, thereby reducing the number of aircraft needed to air transport a given unit and increasing the effectiveness of the available transport support force. Reductions in weight and volume should not be permitted to impair other essential operational characteristics, nor to increase overall costs disproportionately. Whenever possible, reduced weight should be achieved by utilizing noncritical, lightweight materials and taking advantage of advanced designs — not by use of materials which are expensive or in short supply.

Except for equipment items to be carried in the CH-21, CH-34, UH-1B/D, or U-1A series aircraft, the outside dimensions of equipment items must be such as to permit loading and unloading with 6-inch vertical clearance after loading and 5-inch lateral clearance on each side during and after loading. The outside dimensions of equipment items to be carried in the CH-21, CH-34, UH-1B/D, or U-1A series aircraft must be capable of being loaded and unloaded through side cargo doors to provide 1-inch vertical and lateral clearance at the doors and inside the cargo compartment during loading, and 6-inch vertical and 5-inch lateral clearance after loading.

2—9.3 STRENGTH. Equipment should be capable of repeated operation without undue fatigue. Assemblies must be designed and materials selected with sufficient physical strength to insure safety, long life, and dependability.

2—9.4 MOBILITY. Mobility or ease of loading and unloading is an essential requirement. Ground clearance between axles of wheeled vehicles must be sufficient to insure clearance at the juncture of the ramp and cargo compartment. The length-height relationship of the item must be such as to preclude the load from striking the top of the cargo compartment during loading and unloading.

2—9.5 SECTIONALIZATION. Sectionalization of large, bulky equipment should be given full consideration. Disassembly and assembly must be within the capability of user units, and provisions should be made for lifting of heavy components. Sectionalization must not materially impair the capability of an item to perform its fundamental mission. Materiel should be plainly marked as a guide to disassembly and assembly procedures and as to location of the center of gravity of each component. All mobile equipment requiring sectionalization should be designed to permit the basic element to be moved on its own wheeled or tracked system.

2—9.6 SKID-MOUNTED ITEMS. In general, skid-mounted equipment is undesirable from the ground mobility and air transportability standpoint, and should be used only when dictated by the performance requirements of the equipment. If skid-mounted equipment is required, the dimensions fall into the following two categories:

a. The end item equipment mounted on a skid frame structure should be within the maximum dimensional size and capacity of a pallet and/or platform, such as used by cargo loading systems having roller conveyor mobility.

b. High-density, skid-mounted equipment requiring rated floor capacity skid structure and not applicable for pallet and/or platform mobility should be mounted on a steerable, pneumatic-tired trailer.

2—9.7 STACKING CAPABILITIES. Containerized materiel and wheeled equipment with relatively low density should be designed for stacking. Pallets used for container stacking should provide forklift openings for mobility. Attention should be given to stacking as to the structural strength required to withstand the vertical of restraint force requirements when air transported.

2—9.8 LOCATION OF TIEDOWN POINTS. Each tiedown point on equipment for air transport must have adequate restraint capacity for a minimum of 10,000 pounds in all directions.. Detailed requirements for tiedown provisions for items to be airdropped are contained in MIL-STD-814A[5]. Detailed design requirements of tiedown fixtures required on military equipment for air transport are contained in MIL-STD-209[42]. The selection of tiedown locations for air transport can be made using the following rules as guidance:

a. The number of locations for attachment fittings shall not be less than four.

b. Locate the tiedown points on the equipment structure which will provide at least 10,000-pound restraint capabilities, in a symmetrical pattern as near as possible about the longitudinal and transverse gravity center point level.

c. Place the same number of tiedown points on each side and each end of the equipment.

d. Locate tiedown eyes so as to provide a 45-degree working cone from the vertical. Where applicable, tiedown eyes shall be located so as to restrain the sprung weight; e.g., chassis of wheeled vehicles or hulls of tracked vehicles.

2—9.9 ELECTRICAL REQUIREMENTS. Electrical power availability in military and commercial aircraft varies in types and power factors. Designers or managers of end items requiring heating, cooling, or energizing enroute or in storage are cautioned to furnish the necessary aircraft ground support equipment to satisfy such requirements, including a standby power source to be used in the event external power fails or is found to be unavailable at enroute stations.

2—9.10 AIRCRAFT CHARACTERISTICS. Development of material with the required degree of transportability requires careful consideration of the characteristics of the aircraft in which the item is to be air transported. Characteristics of certain aircraft used for air transport and airdrop are given in Chapter 4.

2-10 AIRBORNE LOADS FOR HELICOPTERS

An inherent characteristic of the helicopter is the cyclic vertical motion produced by periodic loading and unloading of the blades. This is a low frequency motion, and special consideration must be given for airborne loads to be carried in helicopters.

Vertical motion fluctuation is generally a function of the number of blades in the rotor and the rotor RPM? As a rule, the predominant frequency is given by

$$W = B \times \frac{RPM}{60} \qquad (2\text{—}1)$$

where

W = natural frequency, cycle/sec

B = number of blades in rotor

RPM = revolutions per minute.

Any load containing a spring in the form of a shock mount or padding must be checked for its natural frequency. Under no circumstances should the natural frequencies of the system to be carried match the inherent frequencies of the helicopter. The frequency spectrum to avoid is as follows:

Helicopter Model	Cycle/Sec
CH-21	11.7-17.5
CH-34	11.3-17.3
CH-37	13.7-17.9
CH-47	10.2-13.1
UH-1	9.8-11.3

Caution should be used in selecting spring-mounted loads with natural frequencies lower than these, since lower frequencies will be excited as the helicopter rotor comes up to speed.

SECTION IV

EXTERNAL SLING LOADS

2–11 GENERAL

The external transport of cargo by helicopter pertains to that procedure whereby cargo is picked up by, and delivered while suspended from, the cargo hook under the helicopter. The external-load capacities of designated helicopters are listed in Table 2–2. The load capacities given in Table 2–2 are based on standard weather conditions at sea level; that is, a barometric pressure of 29.92 inches of mercury and a temperature of 59°F (15"C). The load capacities may vary, depending on the nature of the cargo, range of the flight, weather conditions (3.56°F change per 1000-feet elevation), and similar operational factors.

TABLE 2–2. HELICOPTER EXTERNAL-LOAD CAPACITIES

HELICOPTER	WEIGHT OF LOAD (lb)
UH-1A	3,000
UH-1B	3,500
UH-1D	4,000
CH-21	5,000
CH-34	5,000
CH-37B	8,000
CH-47A	16,000
CH-54A	20,000

2–12 LOAD STABILITY

All material designed for external transport beneath helicopters must be test flown before acceptance. Full-size mockups can be used for test flying, but they must have the following parameters identical to the final product:

a. Weight

b. Volume (and density)

c. Center of gravity (in all threeplanes)

d. Center of pressure (from all directions)

e. Moment of inertia

f. Suspension points

Since many helicopters exhibit marginally stable characteristics, care should be taken to avoid aggravating this condition with the addition of an external sling load. It has been shown that the addition of a sling load to a helicopter can have an unfavorable influence on the dynamic stability. The system tends to swing in the manner of a double pendulum. A stabilizing influence of the sling load on the motion occurs only if the load is attached near its center of gravity and the hook is near the helicopter's center of gravity. With the hook at some distance below the helicopter's center of gravity, there is in general a long-period, moderately unstable mode. It is advisable to attach the load as close to its center of gravity as possible. Most instabilities caused by external sling loads can be countered adequately by pilot control, if the load is properly attached. Instructions for rigging a typical sling load to assure its in-flight stability are given in Fig. 2–26[43].

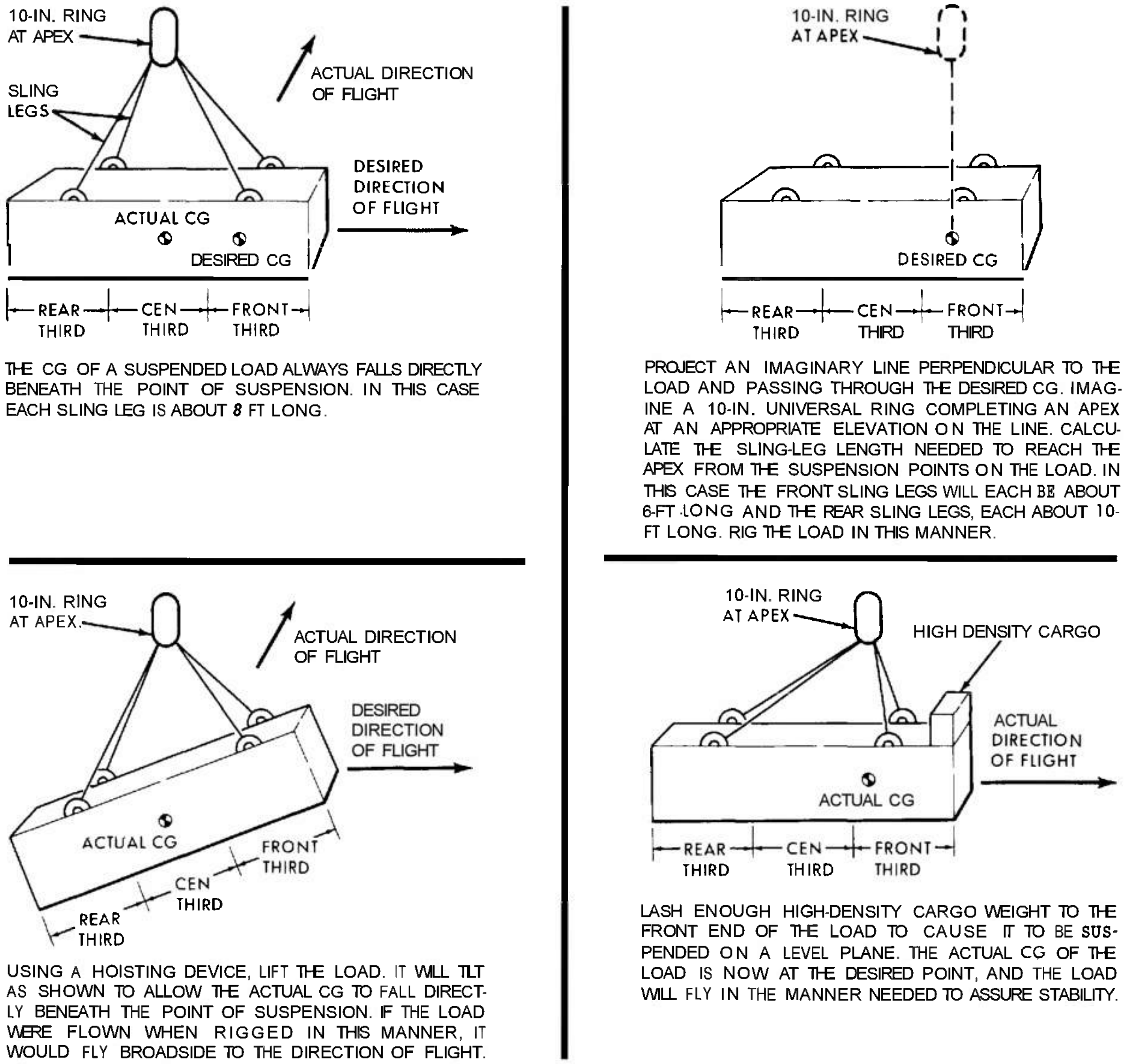


FIGURE 2-26. INSTRUCTIONS FOR RIGGING A TYPICAL SLING LOAD TO ASSURE ITS IN-FLIGHT STABILITY

When lifting objects such as disabled aircraft, a test lift should be made to determine the load center of gravity and to assure that the lift can be accomplished. Normally, fixed-wing aircraft will require spoilers to be attached to them to prevent aerodynamic forces from lifting them toward the bottom of the recovery helicopter. An example of spoilers installed on fixed-wing aircraft is shown in Fig. 2—27. Also for fixed-wing aircraft, the flight controls must be locked or set in neutral position.

If the disabled aircraft has unstable aerodynamic characteristics in yaw, such as the CH-47A, it can be stabilized by means of a ribbon-type drag chute of approximately 20 feet in diameter. The drag chute should be attached to each rear gear, with the top of the uninflated chute a minimum of 40 feet from the gear.

2—13 STATIC ELECTRICITY DISSIPATION

In flight a helicopter generates and stores a charge of static electricity. When

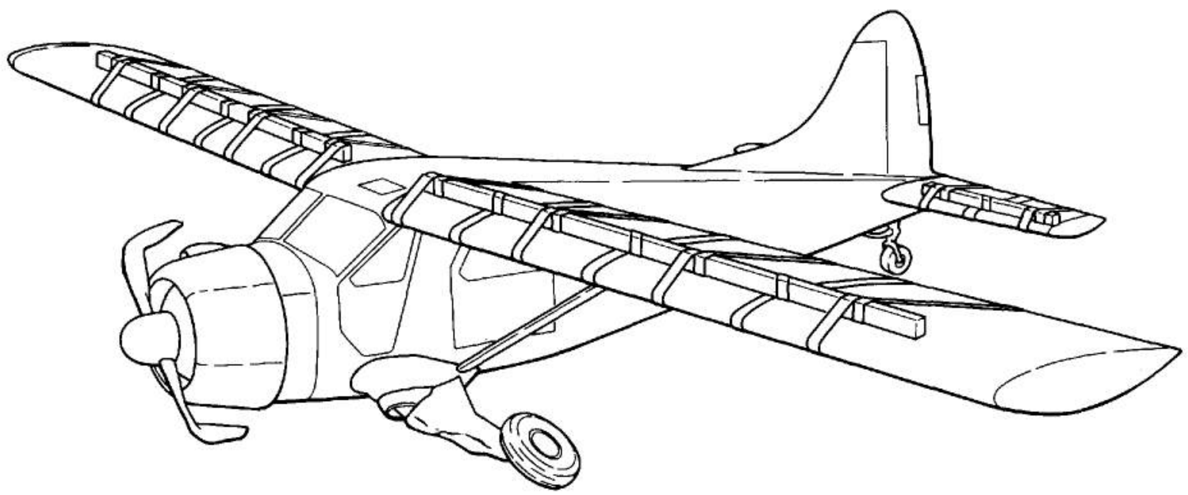


FIGURE 2–27. SPOILERS INSTALLED ON FIXED-WING AIRCRAFT

the helicopter lands, this charge is grounded out; however, while it is in flight, this charge tends to remain stored unless a path is provided for it to be released into the earth. If a ground crewman contacts the cargo hook of a hovering helicopter, he will provide this path.

To avoid the possibility of a ground crewman receiving a static-electricity shock, the charge of static electricity must be dissipated. One method of accomplishing this is with a probe such as shown in Fig. 2—28. The probe consists basically of an insulated aluminum contact tube joined to a metallic tape or wire, which in turn is attached to a ground rod. In use, the ground rod is driven into the earth and the contact rod is held by a ground crewman. As the helicopter hovers over a cargo hookup/release point, the crewman contacts, and holds, the contact rod against the cargo hook, thus grounding out the stored electrical charge. Once the ground crewman grasps the hook, the probe may be released from contact with the hook.

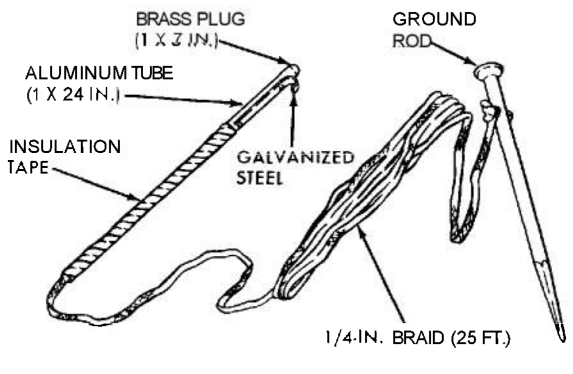


FIGURE 2–28. STATIC DISCHARGE PROBE

2–14 USE OF CARGO NET

The cargo net (Fig. 2—29), designed for external transport of cargo by helicopters, has a load capacity of **5000** pounds. The flat, mesh-type net weighs 37 pounds, is made of 1/8-inch steel cable, is about 16 feet long and 11 feet wide, and can be rolled into a coil 24 by 15 inches. There are five steel eyelets positioned on each side of the net. Each side has a 1/4-inch draw cable, 11 feet long, threaded through each eyelet. Three cables have a snap fastener at one end and a 2-3/8-inch-diameter steel ring with a snap fastener at the other end. The fourth cable has a 6-inch diameter steel ring on one end and a snap fastener on the other end.

2–14.1 GENERAL RIGGING PROCEDURES. The weight and configuration of a cargo item determine whether or not it can be transported in a cargo net. General rigging procedures are as follows:

a. Spread the net evenly on a flat surface and position load to be transported so

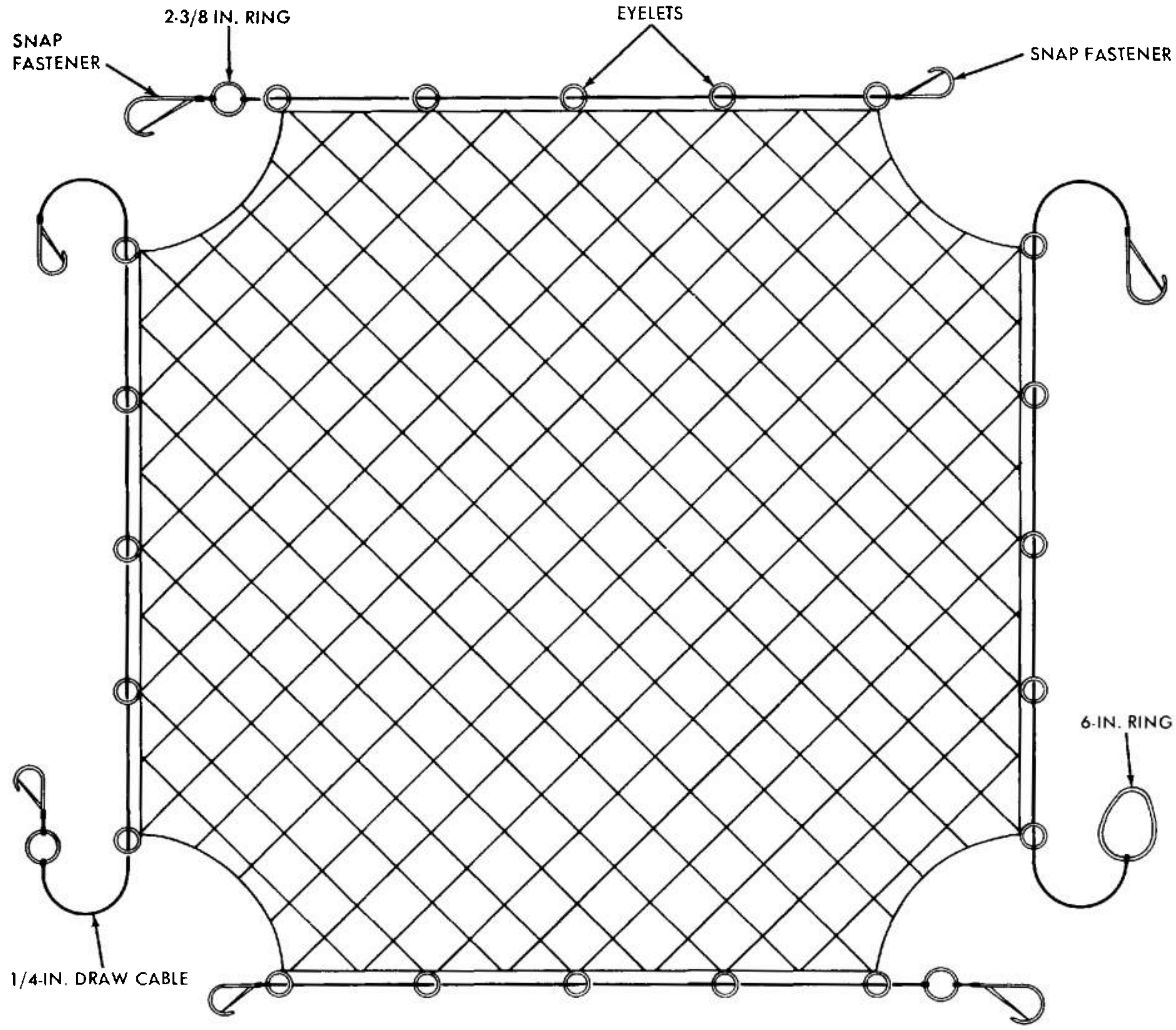


FIGURE 2–29. CARGO NET

that its center of gravity lies in the center of the net. For a composite load, the items should be stacked evenly from the center outward. The load balance must be maintained to insure that the net will suspend levelly when lifted at its apex, the 6-inch ring. For loading numerous small items, a unitized load can be secured to a pallet and the pallet loaded into the net. A composite load of fragile items, such as medical supplies or electronic equipment, should be cushioned with paper honeycomb, cellulose wadding, or other suitable cushioning material.

b. Draw the net up around the load by using the four 1/4-inch draw cables, and secure the draw cables as shown in Fig. 2—30. To prevent entanglement during hookup, cluster the draw cables and tie the net above the load. If the tie is to be used to hold the load in position during flight, 550-pound-capacity nylon cord (or a suitable substitute) must be used. For some loads, it is desirable to allow the draw cables to break free from the tiedposition during lift-off. In this case, use lightweight string or several wraps of 2-inch, pressure-sensitive tape around the cables below the eyelets.

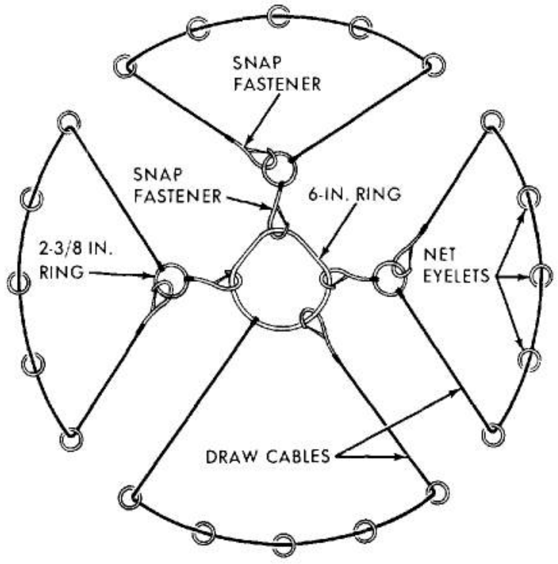


FIGURE 2-30. TOP VIEW OF CARGO NET (DRAW CABLES)

2-14.2 MULTIPLE USE OF NET. A maximum of five cargo nets may be clustered on a single helicopter cargo hook by the use of a multiple leg sling. These slings are issued one per cargo helicopter.

2-15 USE OF UNIVERSAL CARGO SLING SET

The universal cargo sling set (Fig. 2-31) is designed for the external transport of cargo by helicopters. The sling set contains three types of endless, nylon web slings, which are listed as follows:

a. Type I, 10-inch, 5-ply, 10,000-pound capacity (one to a set).

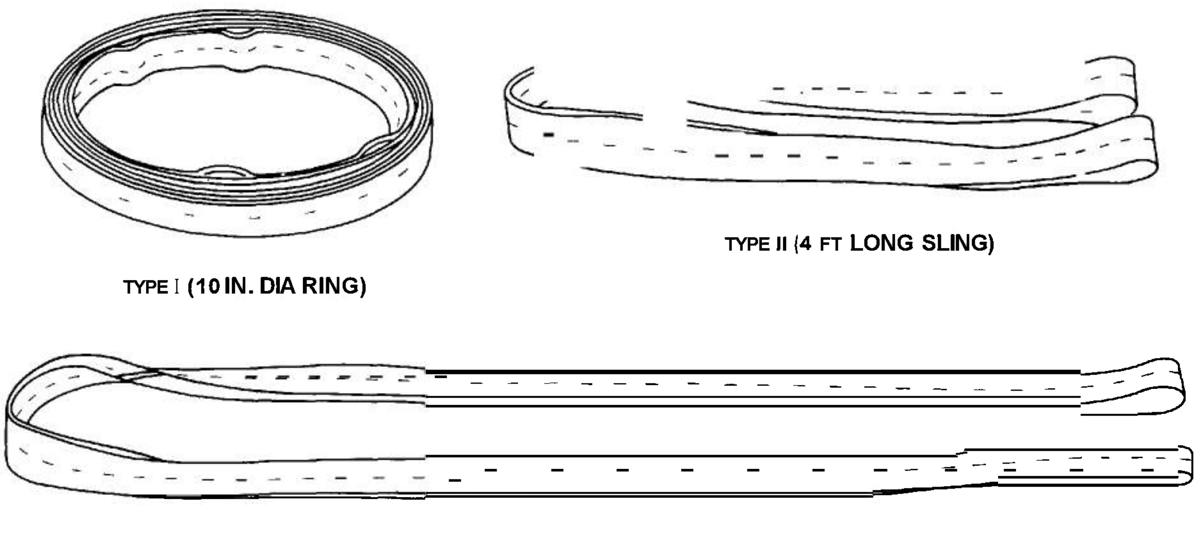
b. Type II, 4-foot, single-ply, 2500-pound capacity (four to a set).

c. Type III, 8-foot, single-ply, 2500-pound capacity (ten to a set).

2-15.1 CONSTRUCTING A TYPICAL CARGO SLING. Three types of hitches are used to connect slings to the cargo item, to each other, or to the 10-inch ring.

2-15.1.1 Choker Hitch. The choker hitch (Fig. 2-32) is used to attach sling legs to the item or to join sling-leg segments to each other. This hitch draws up snugly as the pull of the load is increased, making it difficult to detach slings from the item or to separate sling-leg segments after a lift. For this reason, it is not normally used for loads exceeding 2500 pounds per sling leg.

2-15.1.2 Reverse Choker Hitch. The reverse choker hitch (Fig. 2-33) is used to attach sling legs to the 10-inch ring when the apex of the cargo sling is being formed.

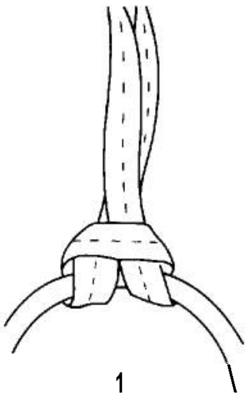


TYPE I (10 IN. DIA RING)

TYPE II (4 FT LONG SLING)

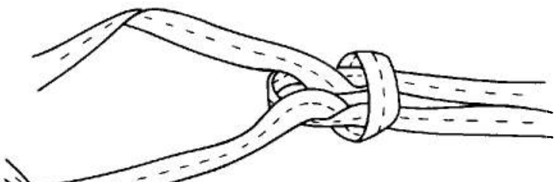
TYPE III (8 FT LONG SLING)

FIGURE 2-31. UNIVERSAL CARGO SLING SET



1

SLING TO FIXTURE



2

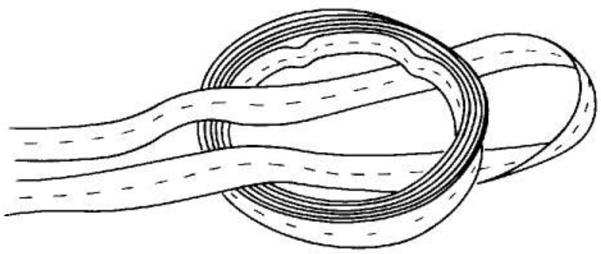
SLING TO SLING

FIGURE 2–32. CHOKER HITCH

2—15.1.3 Basket Hitch. The basket hitch (Fig. 2—34) is used to attach sling legs to the item or to join sling-leg segments to each other. Since it is easy to remove this hitch from the item after a lift and to separate sling-leg segments joined by it, this hitch is normally used for loads exceeding 2500 pounds, but not exceeding the safe working load of **5000** pounds per sling set.

2–1 5.1.4 Folds. The weight distribution and configuration of a particular cargo item may require that the length of the sling legs be adjusted to insure proper flight and balance characteristics of the item. This adjustment may be done by folding the slings as shown in Figs. 2—35 through 2—37. Folds give added strength and lifting capability to the folded sling-leg segments, but it must be remembered that a sling leg or a completed cargo sling is no stronger than its weakest segment.

2–4 5.1.5 Constructing a Typical load. The completed cargo sling (Fig. 2—38) is comprised of sling legs reaching from lifting points on the load to the cargo sling apex at the



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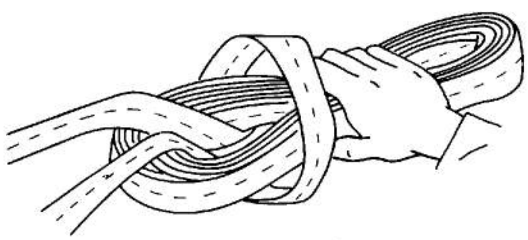

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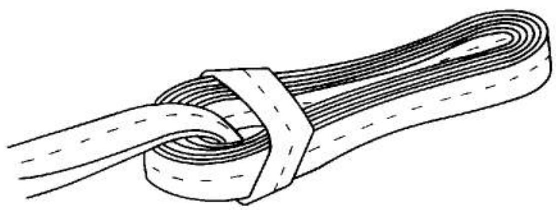


3

FIGURE 2–33. REVERSE CHOKER HITCH

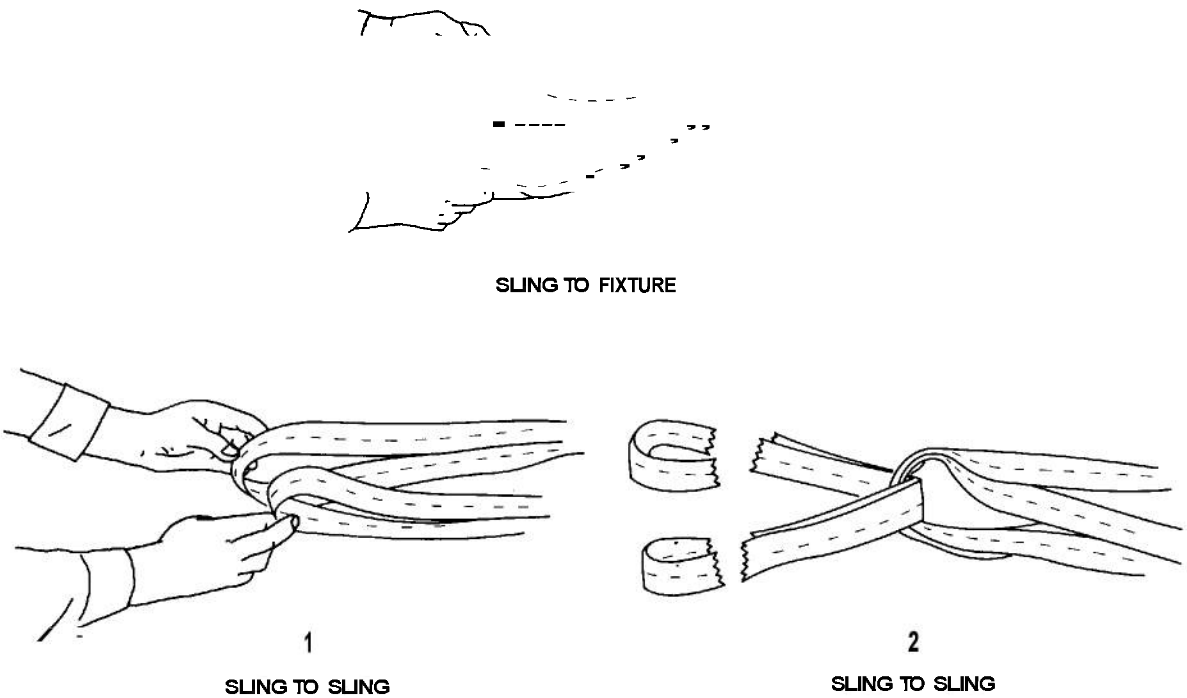


FIGURE 2-34. BASKET HITCH

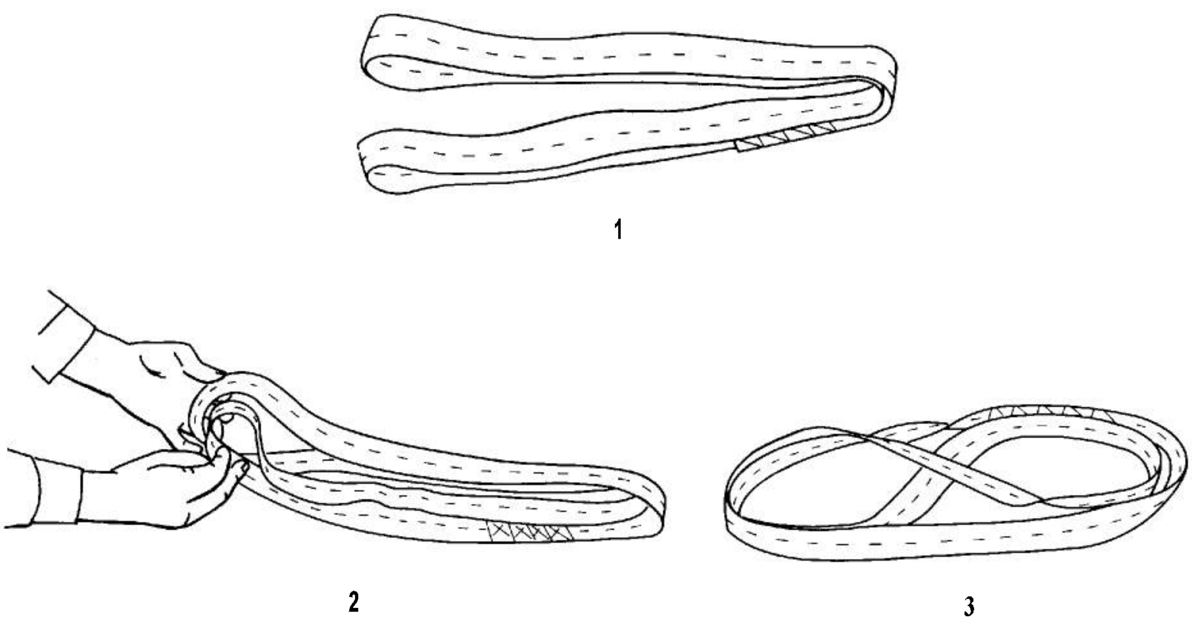


FIGURE 2-35. FOLD

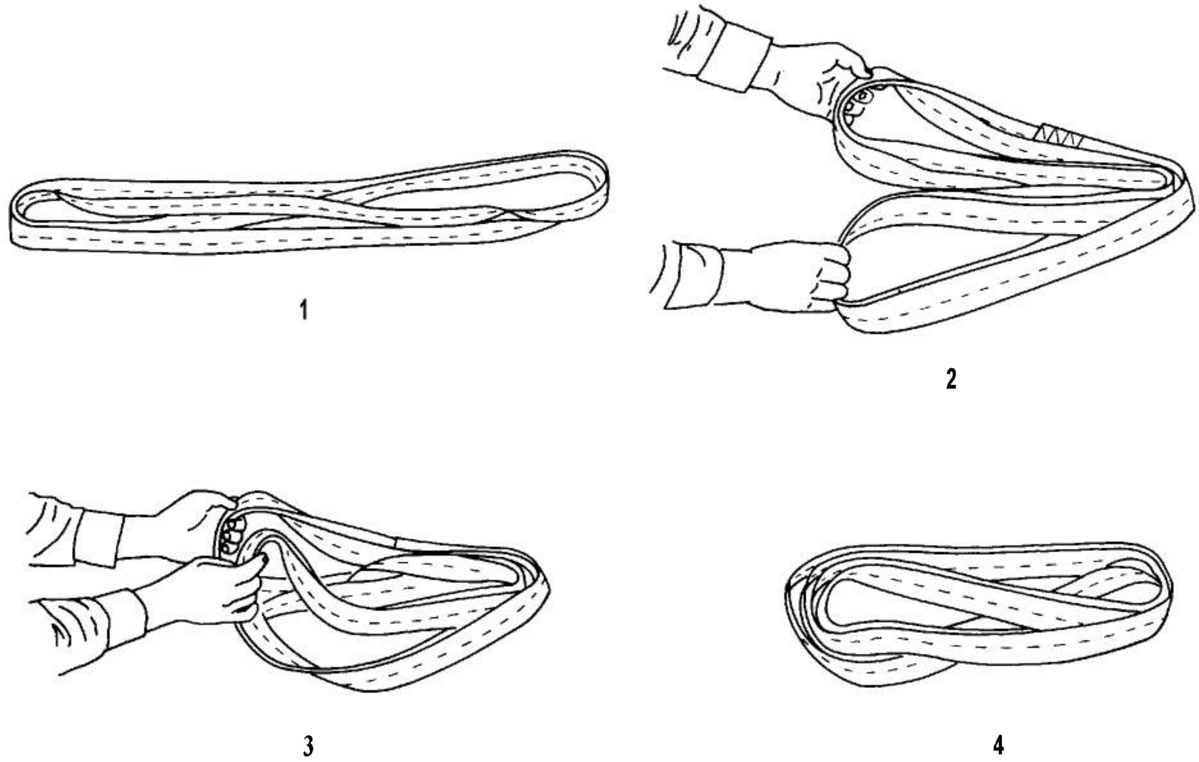


FIGURE 2-36. DOUBLE FOLD

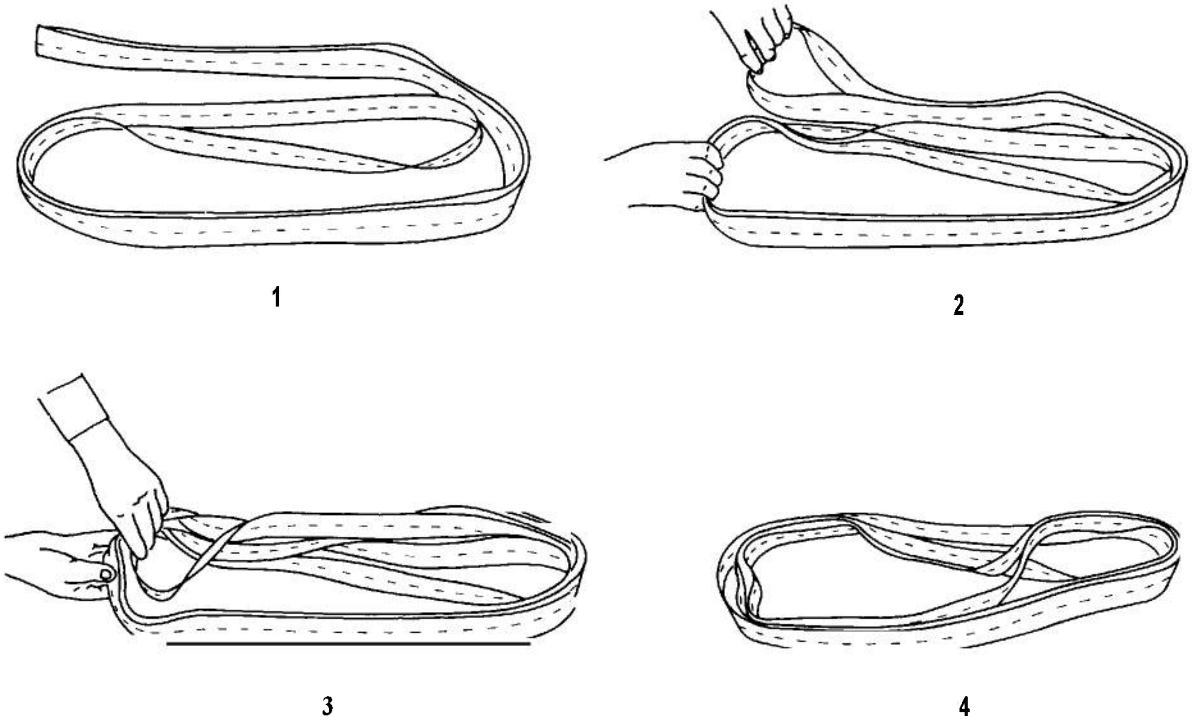


FIGURE 2-37. LAP FOLD

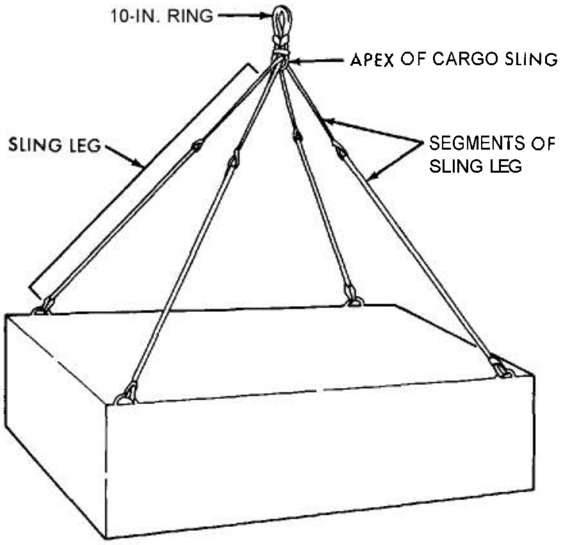


FIGURE 2-38. TYPICAL CARGO SLING LOAD

10-inch ring. Each sling leg may be a single sling or made up of two or more sling-leg segments. The 10-inch ring is used to complete the cargo sling by joining the sling legs at their apex, and to couple the rigged load to the helicopter cargo hook. The free ends of the sling legs may be individually attached to the 10-inch ring, or pairs of sling legs may be combined to form single loops for attachment to the ring. The pairing of legs is usually done when there is an even number of legs. The sequence of hitching the sling legs to the ring is governed by maintaining the center of gravity of the load beneath the sling apex. The sling legs should be taped together to prevent fouling of the cargo sling during hookup. Any sling hitched next to, or resting against, an. abrasive surface of a cargo item should be wrapped with a suitable cushioning material.

In rigging a composite load, it is necessary to lash its components securely to each other for cohesion of the load during transport. Fifteen-foot, cotton-web tiedown straps are useful for this purpose.

2-15.2 EXCEPTION FOR CH-37 HOOKUP. The rigging of universal cargo ,slings to a cargo load applies to all helicopters listed in Table 2-2 except the CH-37. The CH-37 helicopter requires that a large clevis assembly be attached to the 10-inch ring. This device is needed because the CH-37 cargo hook can snag the 10-inch ring and prevent it from falling off the hook during the cargo-release operation. Since the impact of the clevis against the top of the sling load during the release operation may damage a sensitive load, the top of the load should be covered with a 3-inch layer of paper honeycomb.

CHAPTER 3

DESIGN CONSIDERATIONS FOR AIRDROP MATERIEL

SECTION I

INTRODUCTION

3—1 GENERAL

Airdrop involves all types of air-to-ground delivery of supplies and equipment rigged for airdrop from aircraft. It is used mainly to support the conduct of two types of military operations. The first is mass assault, where large numbers of personnel, supplies, and equipment are airdropped into enemy-held territory to establish a position; the second is resupply, where such items as rations, ammunition, water, fuel, and medical supplies are airdropped into territory held by. friendly forces in order to replenish dwindling stocks.

Current airdrop systems require the use of parachutes for aerial delivery of vital supplies and equipment in an operational condition in support of the above combat operations. These parachutes must be designed to meet the criteria of deployment speed, deployment altitude, desirable stability characteristics during descent, rate of descent, and weight of the load to be recovered. These conditions establish the number and size of the parachute based on a certain drag coefficient applicable to each design. In general, an airdrop system should be designed with the following considerations in mind.

a. The maximum tolerable shock loads during deployment and the direction of these shock loads in relation to the cargo.

b. The maximum vertical-fall distance permissible before terminal velocity is reached.

c. The specific stability requirements for the particular cargo being dropped.

d. The rate of descent desirable during any stage or reefed condition.

e. Suspension design in relation to tenter of gravity of the load and its attitude for landing.

f. Conformation to available space in aircraft prior to and during exit.

g. The anticipated range of launching speed and altitude for drop.

h. The anticipated aircraft to be utilized and its characteristics and capabilities in regard to load extraction or ejection.

i. The minimum and maximum weights possible for the system, including platforms or containers, and parachutes.

j. The determination of whether to use expendable or reusable containers or platforms.

k. A reliable, uncomplicated, deployment system so designed to preclude excessive pitching of the cargo after exit.

l. The provision for rapid exit to keep the drop-dispersion area to a minimum.

m. The point of attachment to the structure of the platform or cargo for the absorption of opening shock.

n. The maintaining of the center of gravity of the aircraft within controllable limits.

o. The attitude of the load prior to main-canopy deployment.

p. The selection of proper material in relation to cost and strength.

q. The ease of packing and handling.

r. The low cost of maintenance.

3–2 BACKGROUND AND HISTORY OF AIRDROP

Air developments throughout the entire period of time, stretching backward through World War I, the Franco-Prussian War, the Napoleonic Wars, and on into antiquity, have contributed devices, machines, and techniques toward air supply. In 1783, Joseph-Michel de Montgolfier, designer of the first balloon to achieve manned flight, remarked that "large balloons might be employed for victualling a besieged town. . ." This was the first recorded mention of air as a means of supply in a military operation. Isolated incidents involving airdrop of supplies were recorded during World War I. Prior to World War 11, several European countries were conducting training for large-scale airborne and airsupplied military operations. The airdropping of water, fuel, food, medical supplies, and equipment to sustain military forces on the ground is sometimes regarded in this country as a development solely of World War II. The techniques, organizations, and equipment of World War II were adopted and improved during the Korean Conflict.

Air delivery of heavy equipment had its beginning shortly after World War 11. The experiences of World War II had shown that vertical envelopment was a vital tactical requirement, and its adjunct, the delivery of supplies and equipment from aircraft, was equally necessary if this method of warfare was to be employed to its fullest.

The aerial delivery of heavy cargo has now been developed to the point where loads can be safely extracted from an aircraft and, with the use of clustered parachutes and energy-dissipating material for ground impact, can be lowered to the ground with little or no damage to the load. Current development effort is aimed at improving cost, reliability, accuracy, and operational utilization. These efforts will result in new systems and techniques which will increase the usefulness of airdrop operations.

3–3 PLATFORM AIRDROP

Platform airdrop allows ready-to-use equipment to be deployed at strategic areas in an effective and timely manner when other conventional methods of supply would be less effective or even impossible due to geographical barriers. Items too large or too heavy to be packed into airdrop containers are placed onto a platform and secured to the platform by use of lashings or a net. All standard platform loads are rigged in accordance with a joint Air Force/Army publication (TM **10-500/** T. **O. 13C7 series**)[7]. The sequence of events for a platform airdrop consists of the following:

a. Rigging load onto platform (par. 3–24).

b. Transporting and loading the rigged load into the aircraft (par. 3–25).

c. Restraining loaded platform for inflight restraint (par. 3–25).

d. Release of inflight restraint and extraction of platform load (par. 3–26).

e. Recovery parachute deployment and opening (par. 3–27).

f. Descent (par. 3–28).

g. Ground impact, energy dissipation, and derigging of load from platform (par. 3–29).

The standard weight range capability for platform airdrop is 2500 to 25,000 pounds. A new capability to extend this range to 35,000 pounds has been demonstrated and studies are underway to further increase the capability to 50,000 pounds.

3–4 NONPLATFORM AIRDROP

Nonplatform airdrop is the delivery of miscellaneous small items of supplies and equipment in containers (par. 3–19). The rigging of container loads is covered in TM 10-500[7] and is suitable for free drop, high velocity drop, and low velocity drop as defined in TM **10-500.** Nonplatform airdrop consists of door bundles, wing loads or stores, or cargo packed in A-22 containers and utilizing the aircraft's conveyor or monorail system. The maximum unit weight dropped in containers is 2200 pounds.

For door bundles, the containers are pushed or skidded out of the aircraft solely by personnel. The maximum bundle weight shall be **500** pounds, and the minimum shall give a loading greater than 35 pounds per square foot. In wing loads, A7-A, A-21, or M4A containers are rigged and attached to drop load shackles affixed to wings of aircraft adapted for this method of airdrop.

3-5 LOW ALTITUDE AIRDROP

The most important new capability for airdrop and, thus, the one with the most intensive effort being placed upon it, is that of low altitude airdrop[34]. This capability is required for two major reasons. The first is to reduce the vulnerability of the airdrop aircraft and the second is to increase the accuracy of the airdrop. Against an enemy that relies on essentially man-portable firepower, the most dangerous altitudes for aircraft are those below 2000 feet where small-arms fire can be effective in damaging or destroying aircraft. However, when the enemy introduces rather sophisticated air defenses such as radar, antiaircraft batteries, and surface-to-air-missiles, the danger from small-arms fire becomes acceptable when compared to the danger at medium to high altitudes from the sophisticated weapons. In regard to accuracy, the greatest error arises from the drifting of the cargo due to the wind. It is agreed that were the winds known precisely, the aircraft navigator could position the aircraft properly to permit accurate delivery of the cargo. However, in general, cargo aircraft do not carry navigation equipment capable of measuring precisely the total effect of the winds from aircraft altitude to ground level. Thus, the present solution to the accuracy problem is to subject the cargo and its decelerator to the unknown winds for the shortest period of time possible by airdropping from the lowest altitude possible.

3-5.1 PROBLEMS IN DEVELOPMENT. Presently, using minor modifications of standard techniques, cargoes weighing up to 10,000 pounds can be successfully airdropped from altitudes as low as 750 feet. Heavier cargoes require somewhat higher altitudes. It is interesting to consider whether airdrop from altitudes of 500 feet or lower is theoretically possible with the initial conditions encountered in airdrop operations. In the ideal case where the cargo and decelerator are considered a point mass and the cargo is decelerated at constant magnitude independent of velocity, the minimum altitude required for the horizontal velocity of the cargo to be reduced to essentially zero is a function only of the initial velocity and the magnitude of the deceleration. Currently used design values for these parameters are 130 knots airspeed and a maximum force exerted by the decelerator on the cargo equal to 3 g's. With these initial conditions, the minimum altitude possible is found to be approximately 50 feet. Of course, the actual performance is far from the ideal case for a number of reasons. Firstly, the cargo and decelerator do not act as a point mass but deviate markedly from the path of the center of gravity of the cargo-decelerator combination. This results not only from the usual oscillation of unstable parachutes, but primarily, in the case of heavy cargoes with clusters of large parachutes, from the fact that the recovery parachutes, because of their great inertia and their long distance from the cargo, do not remain aligned with the instantaneous velocity vector of the cargo. Rather, the velocity vector of the parachutes lags behind the cargo velocity vector such that when the cargo is retarded to zero horizontal velocity, the parachutes are applying a force with still a large horizontal component. The motion of the cargo that results is a highly damped oscillation which contributes to the amount of altitude required to reach equilibrium conditions (Fig. 3-1). Secondly, with most aerodynamic decelerators, the various tricks, such as staged parachutes, staged reefing, and continuous disreefing used in an attempt to maintain constant retardation force as the velocity decays rarely do the job completely.

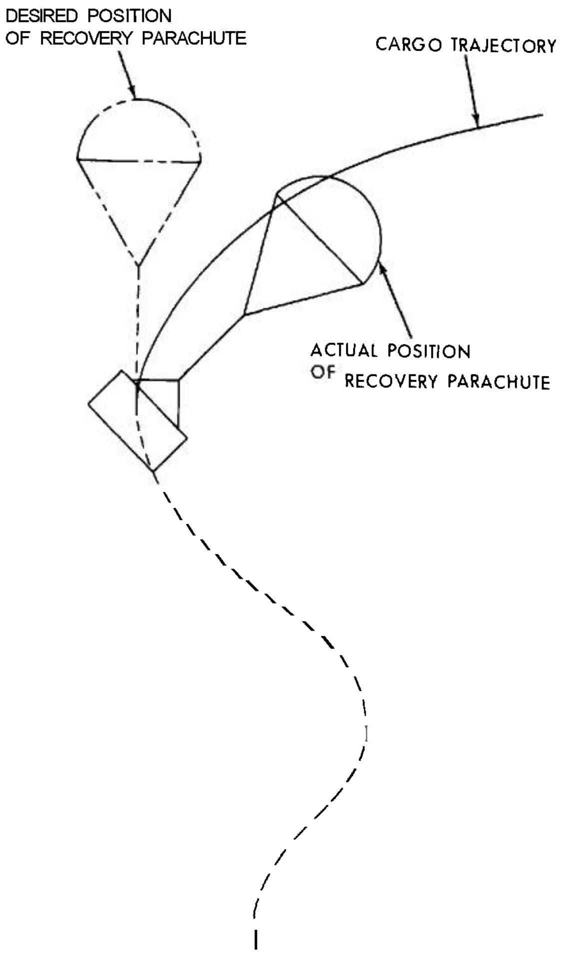


FIGURE 3-7. CARGO OSCILLATION DUE TO LAGGING PARACHUTES

3-5.2 SYSTEM CONCEPTS. In considering the foregoing, it has become apparent that airdrop probably can be conducted at the desired low altitude, but that significant changes in airdrop technique will be required in order to do *so*. Some of the concepts which have been studied are described in the paragraphs which follow[9,35].

3—5.2.1 Extraction by Recovery Parachutes (Fig. 3—2). In this concept, the standard two-stage method of airdrop — i. e., extraction of the cargo from the aircraft using a relatively small ring-slot parachute and recovery of the cargo using clusters of large recovery parachutes — is replaced by a one-stage method where the clustered recovery parachutes, while reefed, are used to extract the cargo and then, after disreef, recover the cargo. This reduces the loss of altitude which occurs during parachute deployment in the standard system.

3—5.2.2 Retro-rocket Deceleration (Fig. 3—3). This concept uses a cluster of small parachutes to stabilize and initially decelerate the cargo. A short time before ground impact, ground-sensing probes fire clustered retrorockets which provide final deceleratioq of the cargo. The velocity of the cargo before firing is approximately 70 feet per second and, at ground impact, is approximately 25 feet per second. The use of retro-rockets alone, without parachutes, has not been considered because of the anticipated problems associated with cargo orientation and stability and because of the rather large size of the rocket motors that would be required to dissipate the total energy of the cargo.

3—5.2.3 Retardation by Aircraft Kinetic Energy (Fig. 3—4). This concept essentially negates the need for aerodynamic deceleration of the cargo by allowing the cargo which is suspended from an overhead trolley to travel down a long parachute-stabilized cable which is towed behind the aircraft. During the motion of the cargo, the cable is alternately winched in and allowed to payout as required. At the time when the vertical and horizontal velocities of the cargo are close to zero, the cargo is released from the trolley and allowed to freefall a short distance to the ground.

3—5.2.4 inflation Aids (Fig. 3—5). This concept considers the use of special devices other than propellant actuated devices to decrease the opening times of the large recovery parachutes. In this study, spring-loaded pockets are located at a number of points about the circumference of the canopy skirt. Preliminary ground tow tests have shown that the radial forces produced by these cusps materially reduce the opening times of the parachutes.

3—5.2.5 Elevation of Recovery Parachutes (Fig. 3—6). This concept uses a gliding parachute or flexible wing to raise the opening recovery

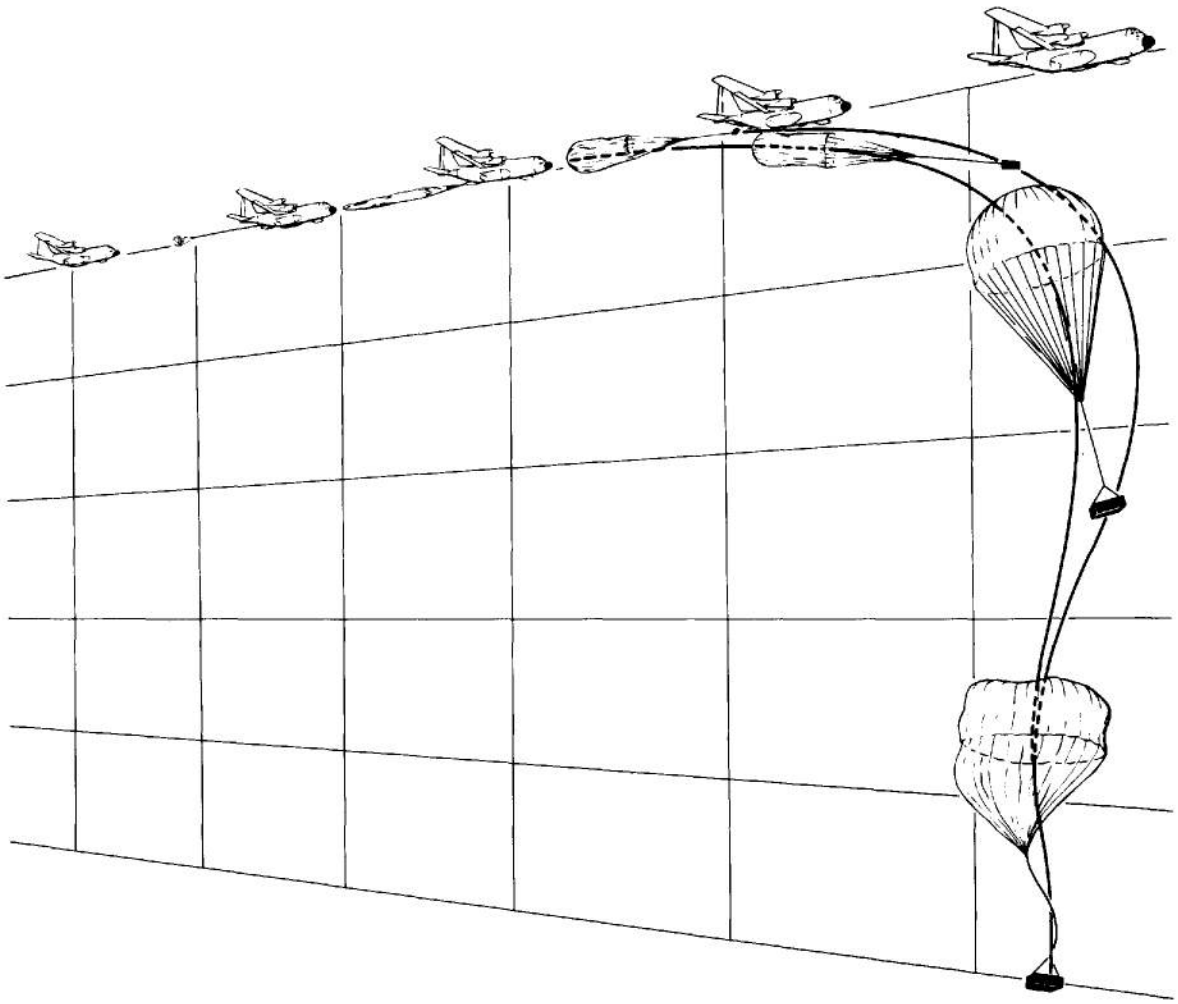


FIGURE 3-2. EXTRACTION BY RECOVERY PARACHUTES

parachutes above their normal zero-lift trajectory and, in some cases, above the flight path of the aircraft. This permits the aircraft to fly at a low altitude and yet allows the parachutes enough time of fall to permit normal canopy opening rates.

3-5.2.6 Parachute Reel-in Reel-out (Fig. 3-7). This concept uses a powered winching device located between the recovery parachutes and the cargo to either decrease or increase the distance between the parachutes and the cargo during the trajectory to (1) maintain high relative velocities of the airstream with respect to the parachutes, (2) reduce the velocity of the cargo with respect to the ground prior to impact, and (3) to relieve unwanted high forces on the cargo at appropriate times.

3-5.2.7 Rotating Decelerators (Fig. 3-8). This concept considers the use of rotors to provide aerodynamic deceleration in place of the recovery parachutes. The particular system being studied incorporates deployable flexible rotors of sufficiently large diameter to preclude the need for flaring prior to impact in order to reduce the impact velocity to an acceptable level. It is estimated that, for a 35,000-pound cargo, a 280-foot diameter rotor would be required.

3-5.2.8 Ground-slide Airdrop. This concept is a very different one from the others in that

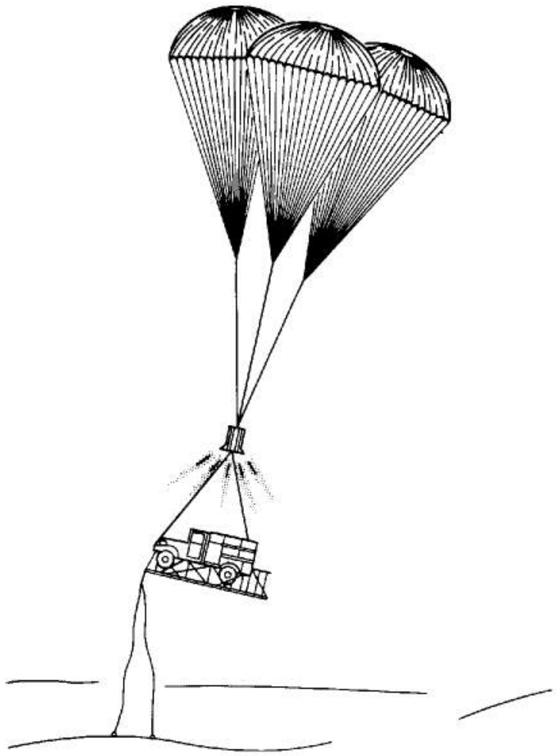


FIGURE 3–3. PARACHUTE RETRO-ROCKET DECELERATION

the horizontal velocity of the cargo is not reduced to near zero prior to ground impact. In this concept, the aircraft flies at an altitude on the order of **10** feet above the ground over a somewhat prepared surface. The cargo is extracted from the aircraft, free-falls to the ground, and slides to a stop. Presently, there are many different systems in various stages of study that fall within this basic concept. One of these employs a ground-based energy absorber (Fig. **3–9)** to extract and horizontally decelerate the cargo. The aircraft trails a tail hook which engages a cross runway pendant which is attached to an absorber unit on either side of the landing site[8]. **A** comparison of ground based energy absorber units is listed in Table **3–1.** Another method consists of using an extraction parachute to extract and horizontally decelerate the cargo (Fig. **3–10).** Figure **3–11** shows the horizontal and vertical velocity components of a cargo dropped from a given height and subjected to a given extraction acceleration at an airspeed of **150** knots.

3–6 HIGH ALTITUDE AIRDROP

In some instances, it may be necessary to airdrop supplies from aircraft flying at altitudes considerably higher than **1500** feet due to the altitude of the drop zone. Recently attention was focused on the possibility that requirement may exist to airdrop personnel, supplies, and equipment onto drop zones which are from **14,000** to 18,000 feet above sea level. In examining

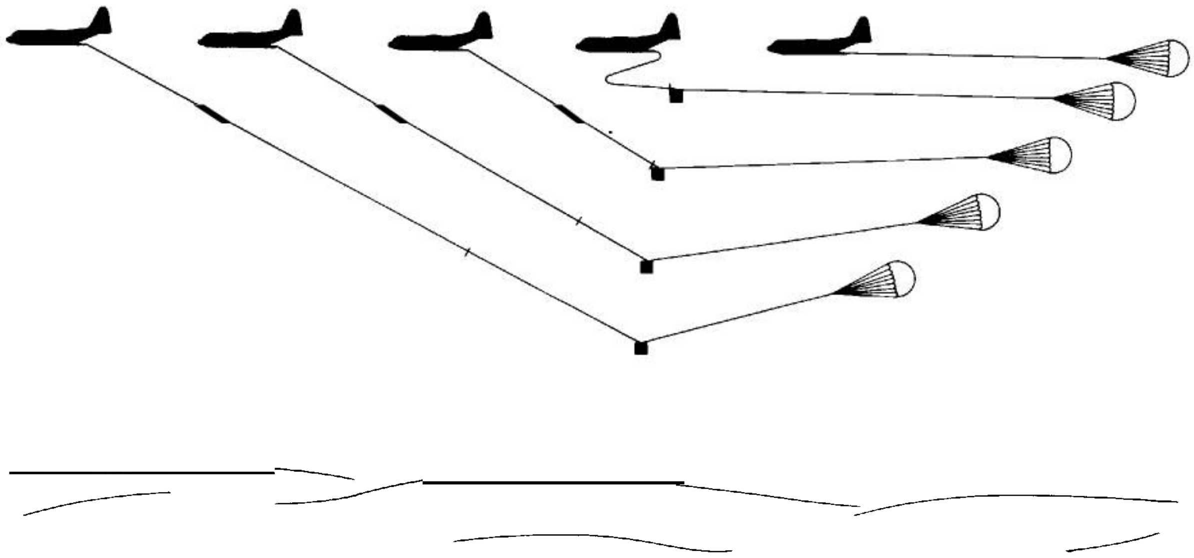


FIGURE 3–4. RETARDATION BY AIRCRAFT KINETIC ENERGY

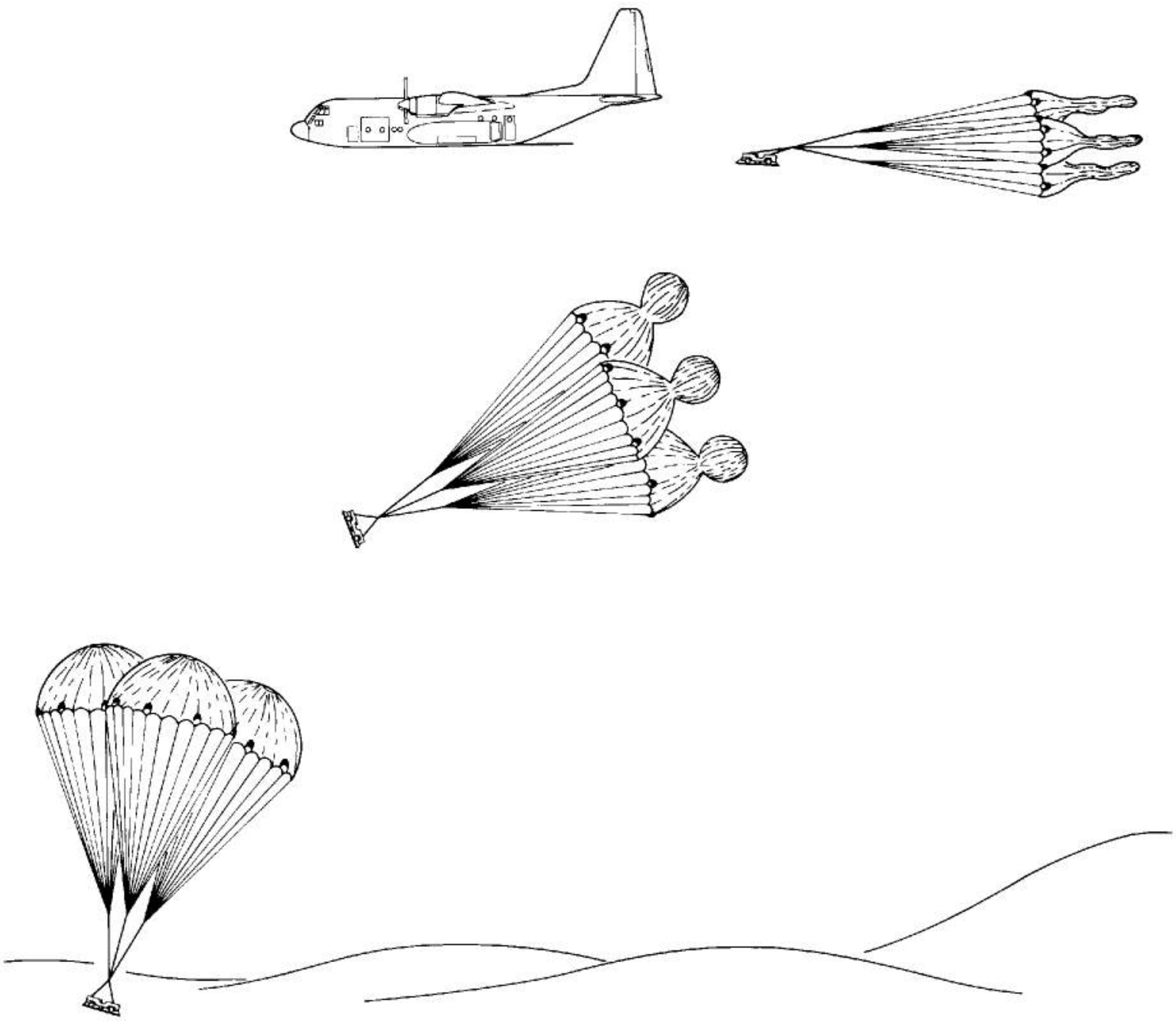


FIGURE 3-5. PARACHUTE INFLATION AIDS

the problems associated with such a requirement, certain factors become apparent which would have a bearing on any contemplated use of lower aircraft altitude for airdrops onto drop zones at high elevations. These factors included increase in rate of descent, increase in time to reach equilibrium velocity and a stable descent.

In other instances, and especially under combat conditions, it may be desirable to airdrop from altitudes that are in excess of **1500** feet above the terrain, regardless of drop zone elevation.

In general, there are two concepts of this type of high altitude airdrop. The first concept involves stabilized high velocity descent of the cargo from a high altitude to a lower predetermined altitude where a second stage of decelerating force is supplied to land the cargo at a low impact velocity. The second concept in high altitude airdrop is that of offset delivery, which is based on the use of a gliding aerodynamic shape such as a paraglider (par. 3—8). Other devices include flexible deployable rotors or steerable gliding parachutes.

3—6.1 ADVANTAGES

3—6.1.1 First Concept. Examining the first concept, the high velocity is desirable because it reduces wind effects, thus providing a more predictable trajectory. The second

TABLE 3–1. COMPARISON OF GROUND-BASED ENERGY ABSORBERS (135 KNOTS ENGAGING

ENERGY ABSORBING DEVICE	20,000 LB		35,000 LB	
	ENERGY ABSORBER WT (lb)	EQUIP REQD FOR FIRST ARREST	ENERGY ABSORBER WT (lb)	EQUIP REQD FOR FIRST ARREST
LINEAR HYDRAULIC	32,145 (2 Units)	15,300 lb H_2O	64,290 (4 Units)	30,600 lb H_2O
LINEAR FRICTION (Sliding Brake Carriage)	3,000 (1 Unit)	———	6,000 (2 Units)	———
ROTARY HYDRAULIC	9,100 (2 Units)	1,200 lb H_2O	17,920 (4 Units)	2,400 lb H_2O
ROTARY FRICTION	5,665 (1 Unit)	16.6 lb H_2O Each Arrest	11,230 (2 Units)	33.6 lb H_2O Each Arrest
METALLIC DEFORMATION	1,420 (1 Unit)	1,080 lb Steel Ribbon Each Arrest	2,840 (2 Units)	1,880 lb Steel Ribbon Each Arrest
LINEAR FRICTION (Internal Feed Ribbon	4,820 (2 Units)	———	9,640 (4 Units)	———
LINEAR FRICTION (Drum Wound Ribbon)	6,020 (2 Units)	———	12,040 (4 Units)	———

stage of deceleration, which reduces the impact velocity to a desirable level, may be actuated by any number of means, including electrical, mechanical, hydraulic, radio, or radar device. One such system employing a radar device is shown in Fig. 3–12. Initiation of the second stage may be controlled from the ground or aircraft if radio devices are employed. This affords an option of destroying the cargo, if there is a danger of its landing in enemy-held territory, by the simple expedient of not initiating the second stage of deceleration.

3–6.1.2 Second Concept. The major advantage of the second concept, as described in paragraph *3–8,* is its ability to glide to a recovery site from a remote release point.

3–6.2 PROBLEMS IN DEVELOPMENT

3–6.2.1 First Concept. Examining the first concept, the second stage of deceleration or main recovery parachute must be deployed at a predetermined height by a height-above-ground sensing device. Two parallel developmental approaches to this problem are being conducted simultaneously — one a radar device and the other a mechanical device. The major developmental effort is being applied to a radar distance-measuring device. This device uses a miniaturized radar transmitter and receiver as the height-above-ground sensing device. This system continuously measures the height of the load above ground until, at a predetermined height, a mechanical device is triggered by the radar signal to deploy the main recovery parachute. The radar device determines the predetermined height above ground by measuring the time for a radar signal to travel from the air-dropped load to the ground and be reflected back to the load. In operation, the radar transmitter sends out an extremely short burst of radio frequency energy; then the transmitter is turned off and the receiver turned on automatically. This procedure is

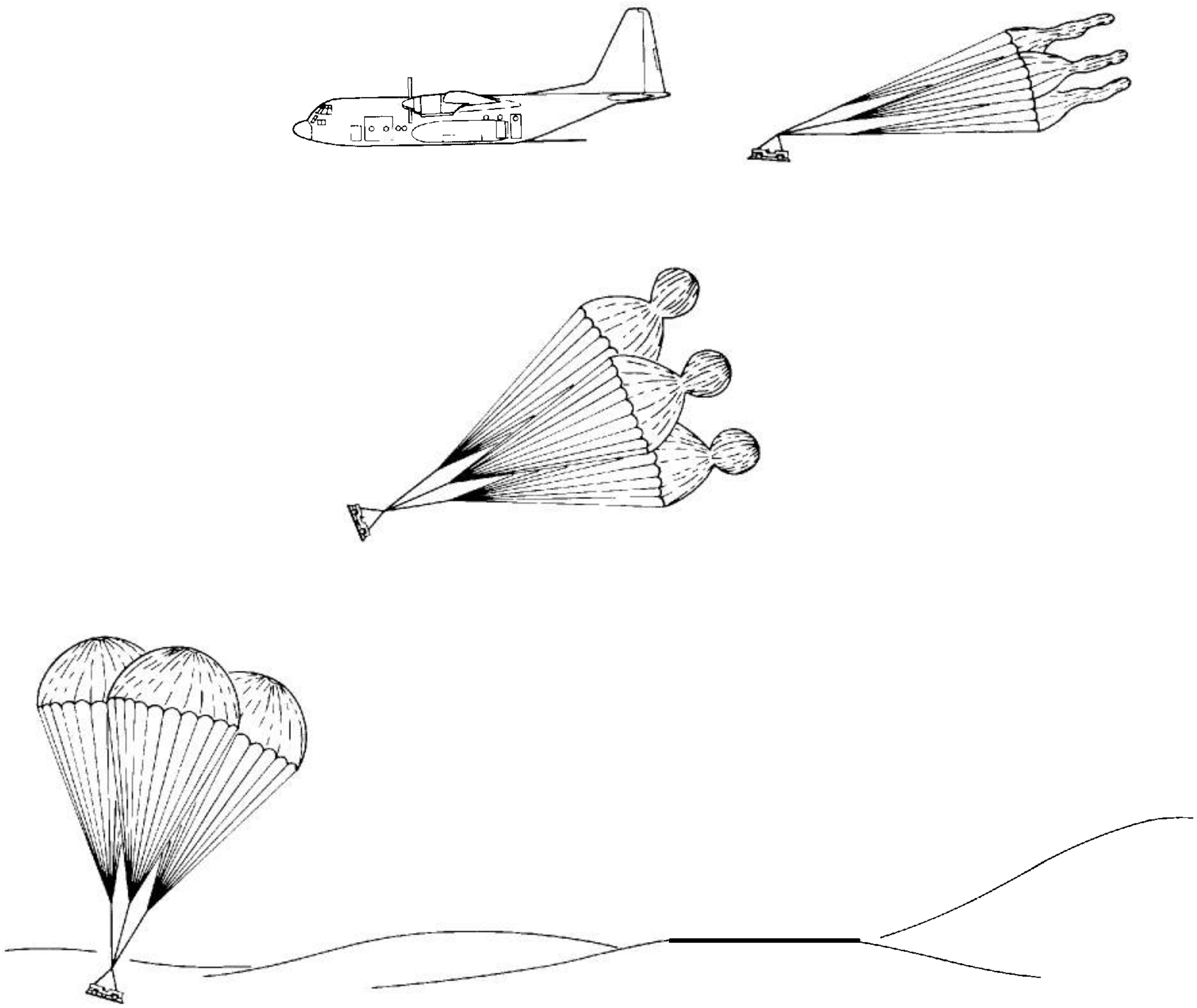


FIGURE 3–6. ELEVATION OF RECOVERY PARACHUTES

repeated continuously and at an extremely high repetition rate. An elapsed time comparison circuit in the device compares the elapsed time of the ground reflected signal with the time built into the system corresponding to the predetermined altitude at which the main recovery parachute is to be deployed. When these two times become equal, the main recovery parachute is deployed to provide a 25-fps ground impact.

The alternate parallel approach uses a mechanical device rather than the radar device in an effort to reduce costs and complexity. This alternate mechanical device consists of a mechanical release and a dropline. In operation, when the dropline touches down, the reduced tension in the dropline triggers the mechanical release and initiates deployment of the main recovery parachute.

3–6.2.2 Second Concept. Examining the second concept, the desirability of good gliding properties is offset in many cases by the necessity for a flare maneuver which is needed to reduce the horizontal velocity which the suspended cargo acquires during flight. The nature of such offset delivery systems involves costs and complexities for which reasonable trade-offs have not yet been established in relation to the military mission for which such systems might be required.

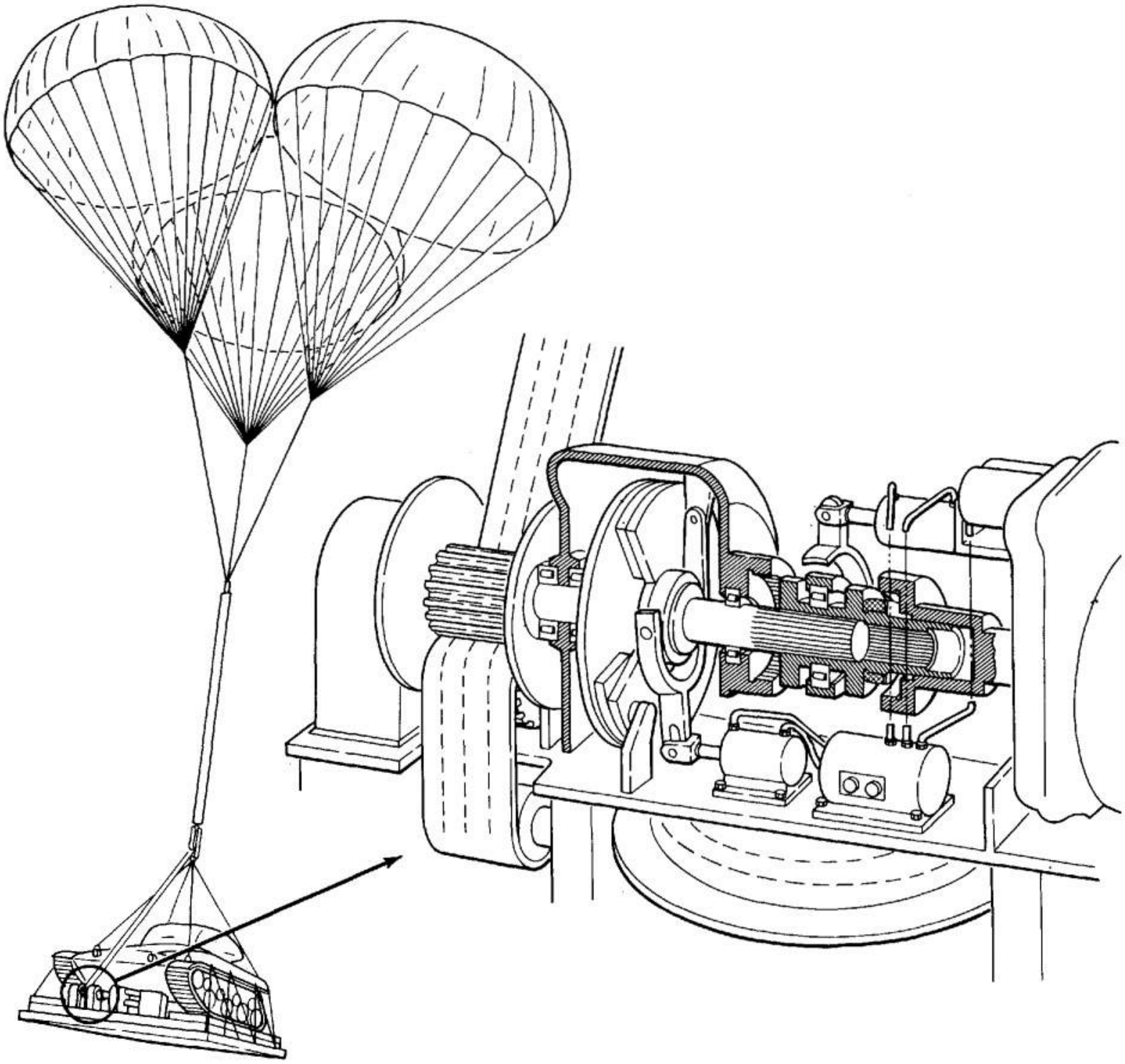


FIGURE 3-7. PARACHUTE REEL-IN REEL-OUT

3-7 AIR PICKUP

Air pickup is the utilization of fixed-wing aircraft to rescue personnel or pick up high-priority cargo where terrain, time, and other factors preclude the use of helicopters or fixed-wing aircraft landing and takeoff operations.

The equipment and procedures necessary to prepare and rig the components of the U. S. Army air/ground pickup system of personnel for airdrop from an appropriate aircraft are outlined in TM 10-500-1. Two different airdrop loads are coveredin TM 10-500-1. One is a kit used when the pickup will be made from land; the other is a water pickup kit. The rigged load for either pickup kit can be dropped from the door or ramp of any aircraft in the normal manner, provided it comes within the bundle limitations of the particular aircraft.

The rigged load of the land pickup kit weighs 25 pounds. It is 48 inches high, 43 inches wide, and measures 20 inches from front to rear. The rigged load of the water pickup kit weighs 297 pounds. It is 36

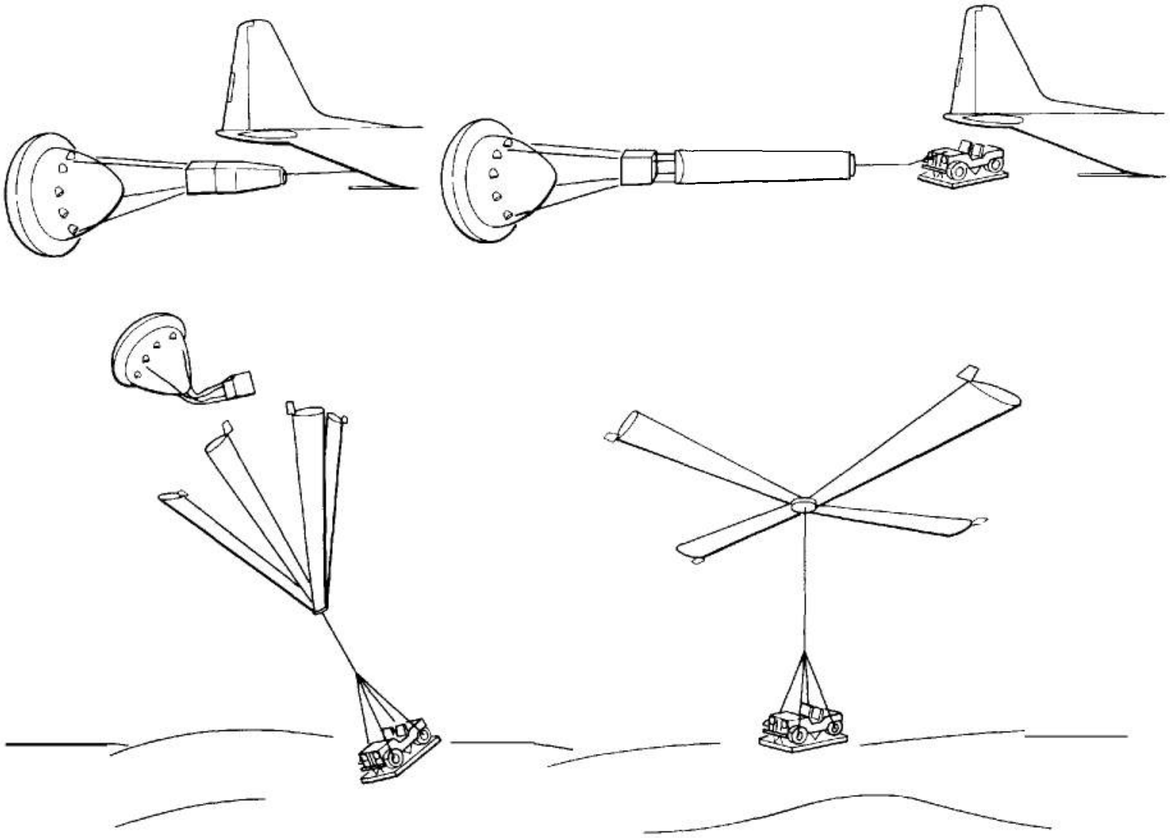


FIGURE 3–8. ROTATING DECELERATORS

inches high, 26 inches wide, and 64 inches long.

3–8 OFFSET DELIVERY

One of the most promising approaches to the concept of offset delivery is the use of a paraglider, sometimes called the Rogallo wing or flex-wing[10, 11, 12]. The paraglider is a flexible, delta-shaped wing that is made by suspending a flexible membrane between a rigid keel and each of two rigid leading edges (Fig. 3–13). The paraglider concept offers the capability of gliding controlled descent.

Packaging characteristics of inflatable versions of the glider are similar to those of parachutes. The glider can be folded and stowed in a comparable space and deployed under much the same circumstances as a parachute (Fig. 3–14). Some versions incorporate rigid wing leading edges and keels with the flexible membrane suspended between them. Recent effort indicates that "limp" paragliders, i.e., shaped planforms without rigidized leading edges and keels, are feasible.

A major advantage of the paraglider is its ability to glide to a recovery site from a remote release point. Glide ratios of 3 to 1 are easily obtainable, so that a release from 10,000 feet will yield a range to impact point of almost 6 miles, or a glider released from 30,000 feet will travel about 17 miles. Glide ratios and ranges of about twice these figures appear possible[11, 13, 14]. Remote release points such as these afford the cargo aircraft maximum safety during delivery near heavy enemy defenses.

Recovery point errors down to a 100-foot radius have been obtained with automatically homing paragliders. The glider is guided by changing the location of the center of gravity with respect to the center of pressure. In some systems, this is done

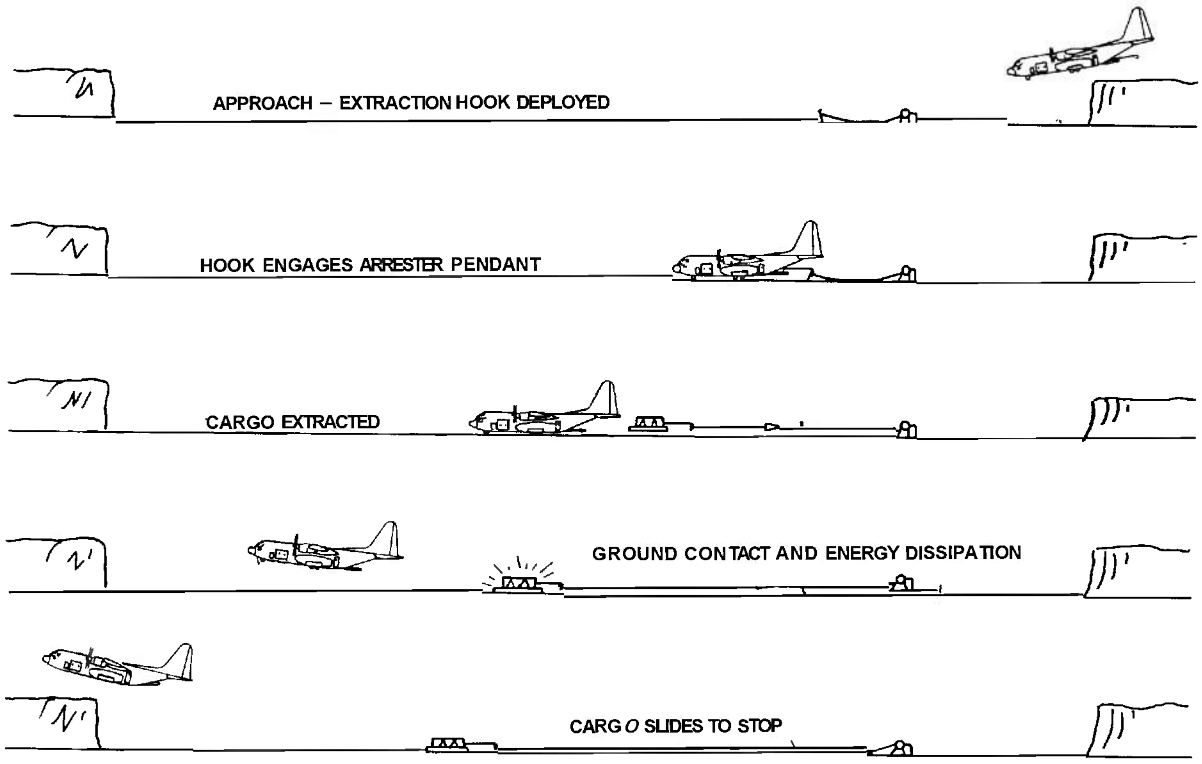


FIGURE 3–9. DELIVERY SEQUENCE WITH GROUND-BASED ENERGY ABSORBER

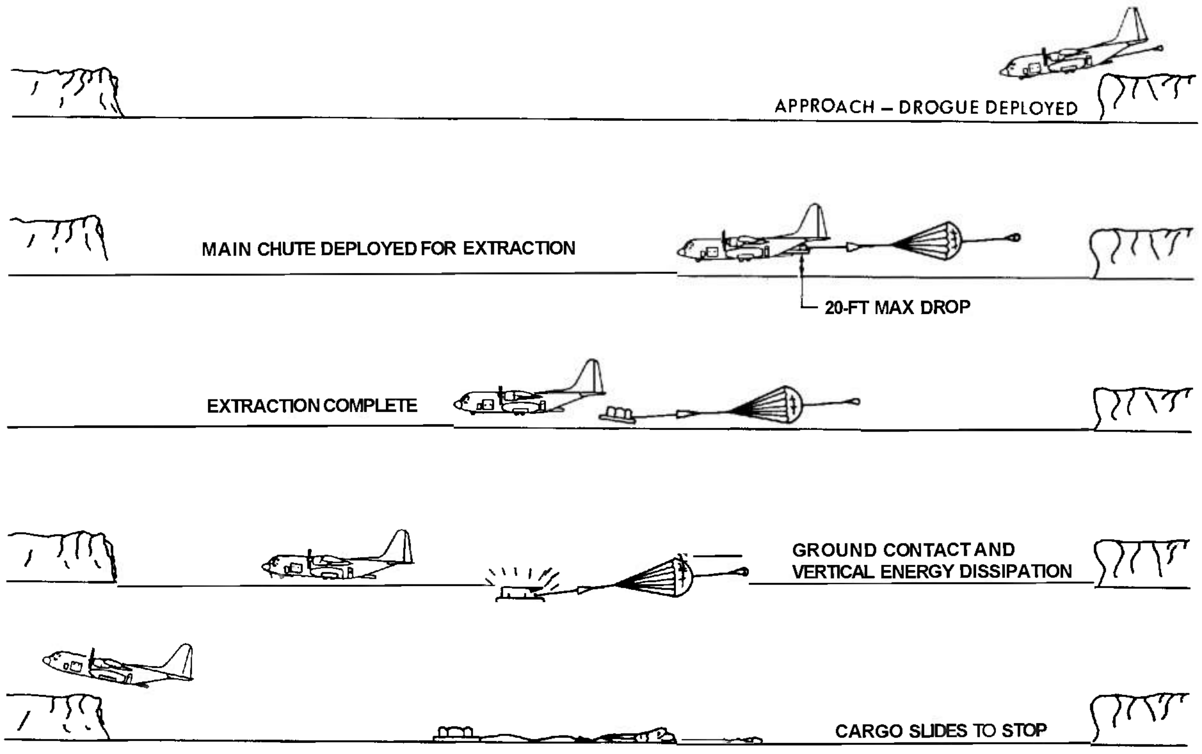


FIGURE 3–10. PARACHUTE DELIVERY SEQUENCE

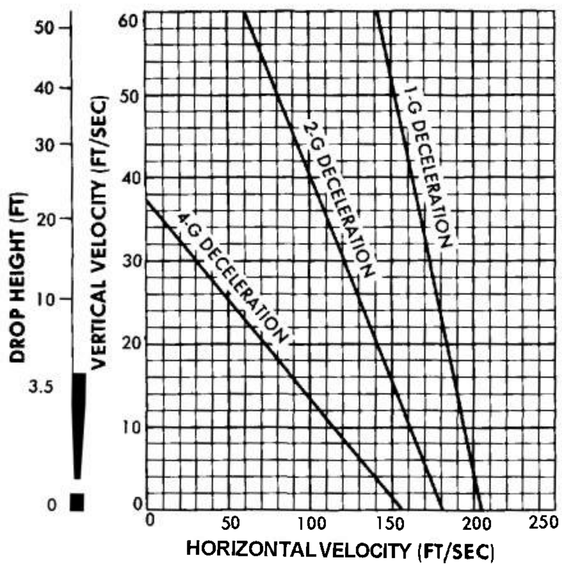


FIGURE 3-11. HORIZONTAL AND VERTICAL VELOCITY VS DROP HEIGHT

by varying the cable lengths with which the load is attached, thereby causing an unbalance which results in a change of the wing attitude. If the unbalance is in the lateral direction, the glider will enter a turn; if in the longitudinal direction, the angle of attack, and consequently the glide ratio, will change. A small radio control receiver is used on the glider to sense direction to a ground-based transmitter and produce turn signals in proportion to the azimuth error. This type apparatus gives the glider a unique all-weather capability by virtue of the fact that it can be launched above an overcast and will proceed to the recovery site automatically.

The landing phase, or flare, of the paraglider is accomplished by increasing the angle of attack of the wing just prior to touchdown. This has the effect of increasing lift and drag, thus reducing vertical and horizontal velocity of the suspended cargo. The design of the flare maneuvers must then consider trade-offs of horizontal vs vertical velocity which can be tolerated by the cargo in making a safe landing.

Paragliders may be configured in any of several different arrangements. The inflatable version may be packed and deployed like a parachute (Fig. 3—14). After deployment, a self-contained inflation mechanism inflates the wing leading edges and keel. Another configuration uses rigid wing leading edges and keel, folded and transported as shown in Fig. 3—15. Loads are suspended either by flexible cable or a rigid structure. Another technique in the use of paragliders is that of towing them with another aircraft, as shown in Fig. 3—16. Towing is accomplished with helicopter or fixed wing aircraft. Helicopters are able to tow payloads near two-thirds of their own *gross* weight[10]. Landing distances of the gliders vary from 200 to 600 feet.

Paragliders are presently under development for delivery of 500-pound cargos. Future effort will concentrate on extending the capability to 2000 pounds.

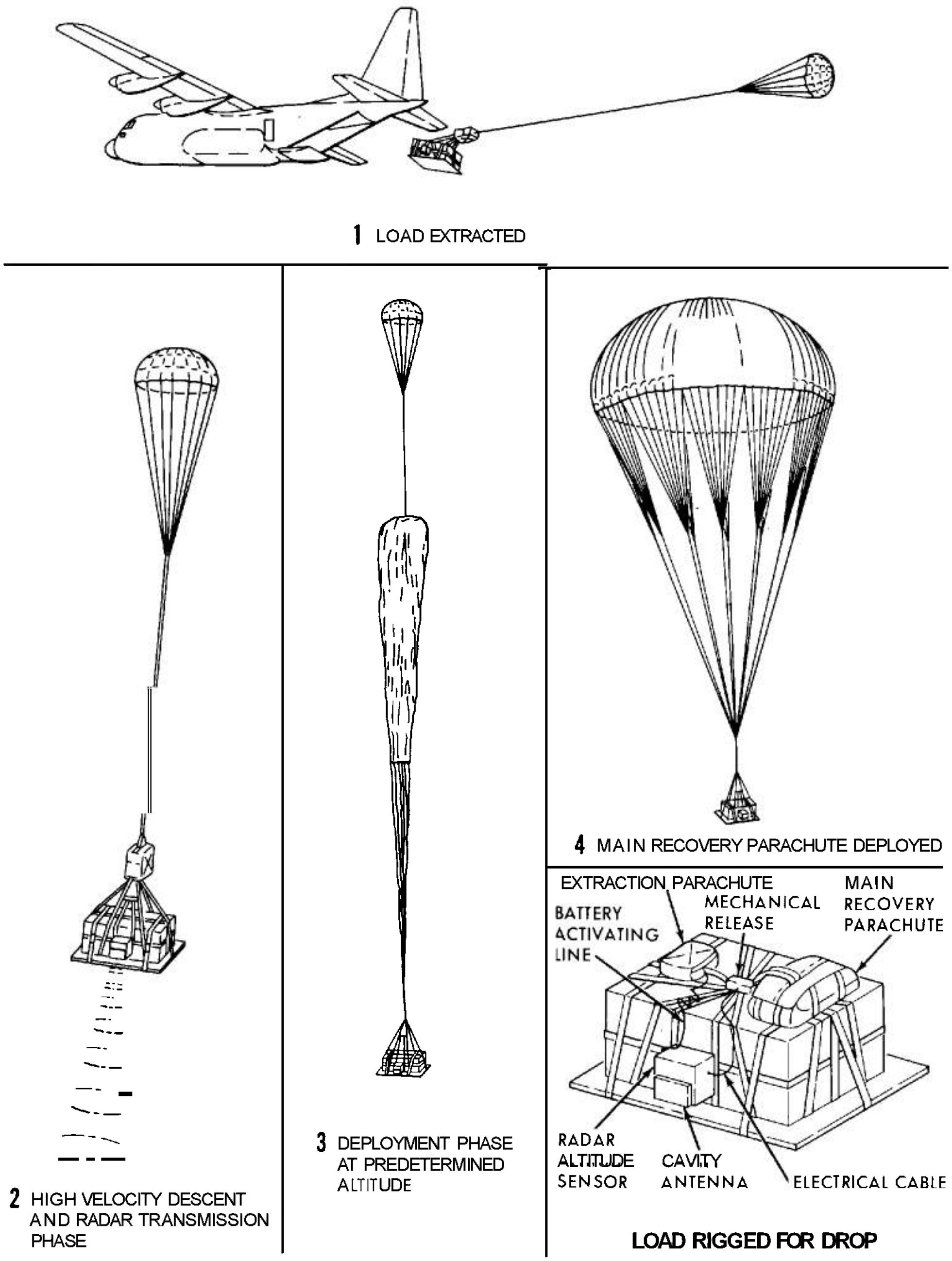


FIGURE 3-12. HIGH ALTITUDE DELAYED OPENING AIR DELIVERY SYSTEM

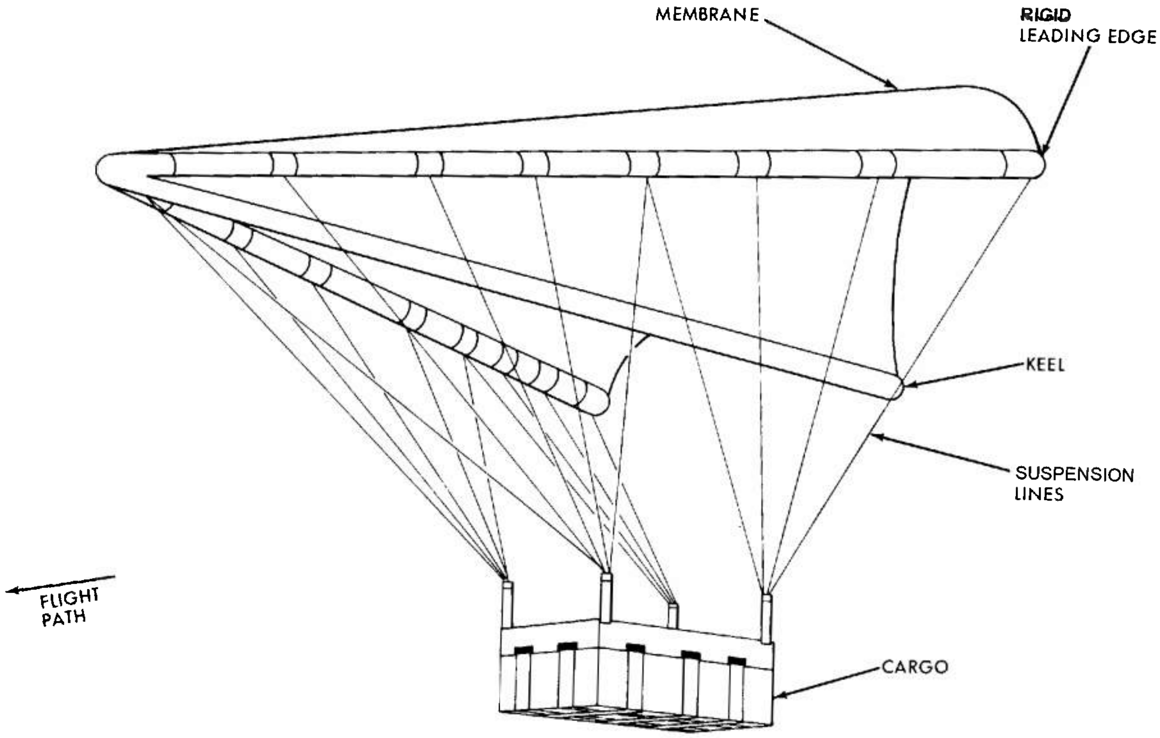
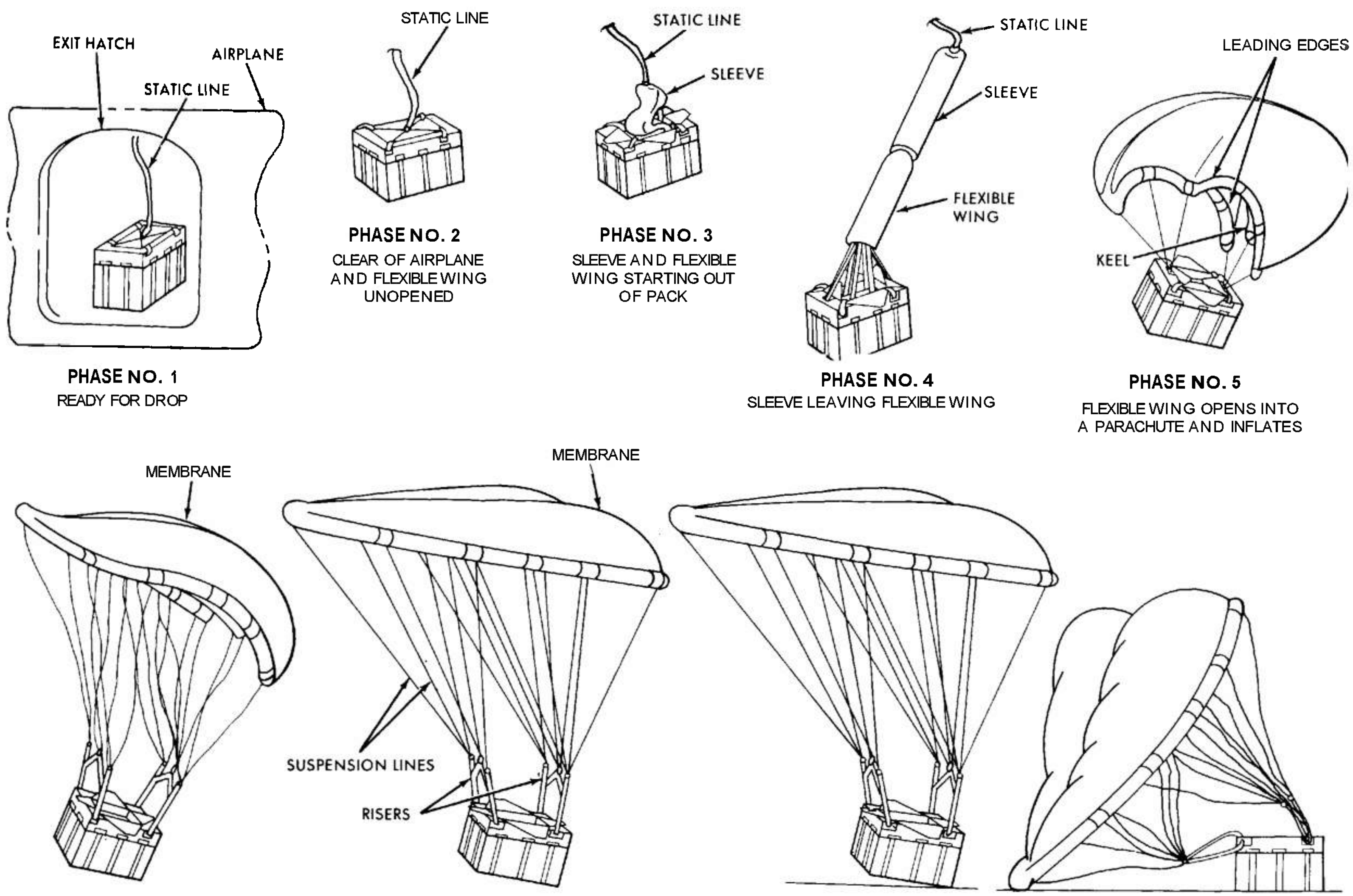


FIGURE 3–13. PARAGLIDER



PHASE NO. 1
READY FOR DROP

PHASE NO. 2
CLEAR OF AIRPLANE AND FLEXIBLE WING UNOPENED

PHASE NO. 3
SLEEVE AND FLEXIBLE WING STARTING OUT OF PACK

PHASE NO. 4
SLEEVE LEAVING FLEXIBLE WING

PHASE NO. 5
FLEXIBLE WING OPENS INTO A PARACHUTE AND INFLATES

PHASE NO. 6
FLEXIBLE WING IN TRANSITION FROM PARACHUTE TO WING

PHASE NO. 7
FLEXIBLE WING INFLATED AND IN PREDETERMINED GLIDE PATH

PHASE NO. 8
CARGO CONTAINER IMPACTING

PHASE NO. 9
LANDING OF CARGO CONTAINER AND FLEXIBLE WING

FIGURE 3–74. PARAGLIDER DEPLOYMENT SEQUENCE

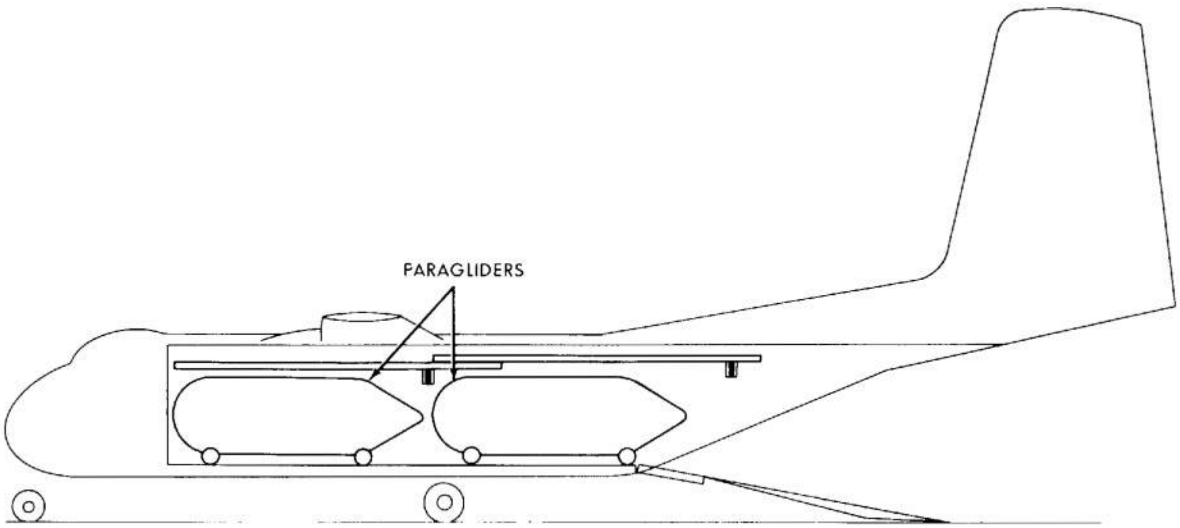


FIGURE 3-15. TRANSPORT OF PARAGLIDER IN CV-2 AIRCRAFT

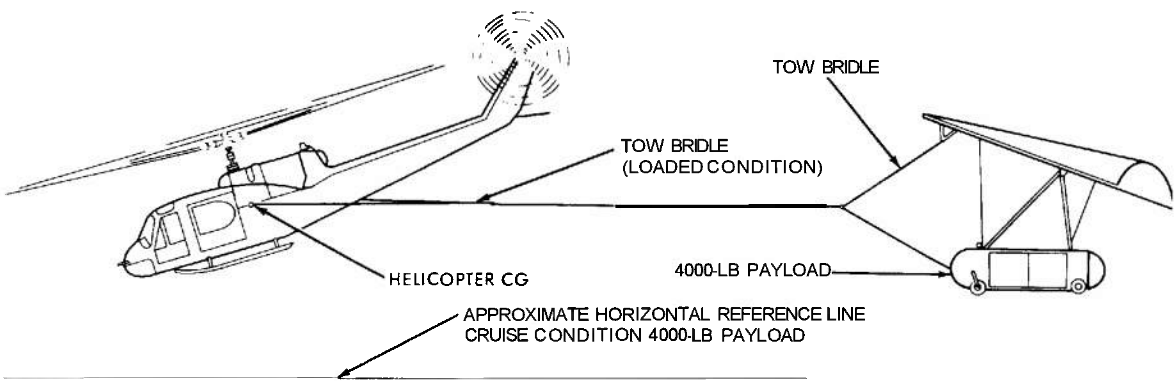


FIGURE 3-76. TYPICAL PARAGLIDER DELIVERY USING HELICOPTER

SECTION II

AIRDROP EQUIPMENT

3–9 SKATE WHEEL AND BUFFER BOARD SYSTEM

The skate wheel and buffer board system is used in CV-2 and C-119 aircraft (Figs. 3–17 and 3–18). This system consists of skate wheel roller conveyors and forward and side buffer boards. The skate wheel roller conveyors, Military Specification **MIL-C-5927B,** facilitate the movement of cargo as it leaves the aircraft. The conveyors are secured to the cargo floor with tiedown clamps. Conveyors for the cargo compartment are assembled from sections of conveyors either 8 or 10 feet long and 1 foot wide. Ramp conveyors for the CV-2 aircraft are **44** inches long. Each conveyor section has a rod at one end and two hooks at the other, making it possible to hook the sections together end-to-end to make a column as long as required. The conveyor frames are aluminum alloy and the axles and skate wheels are steel. Holes are provided in the frames to allow the sections to be bolted together when sections of the same length are placed side by side.

The side buffer boards are installed in the aircraft to enclose the cargo between smooth surfaces, in order to prevent the cargo from being obstructed as it leaves the aircraft. The forward buffer boards are installed on the conveyors to prevent forward movement of the cargo after the tie-downs have been removed. If the location of each load is predetermined, the forward

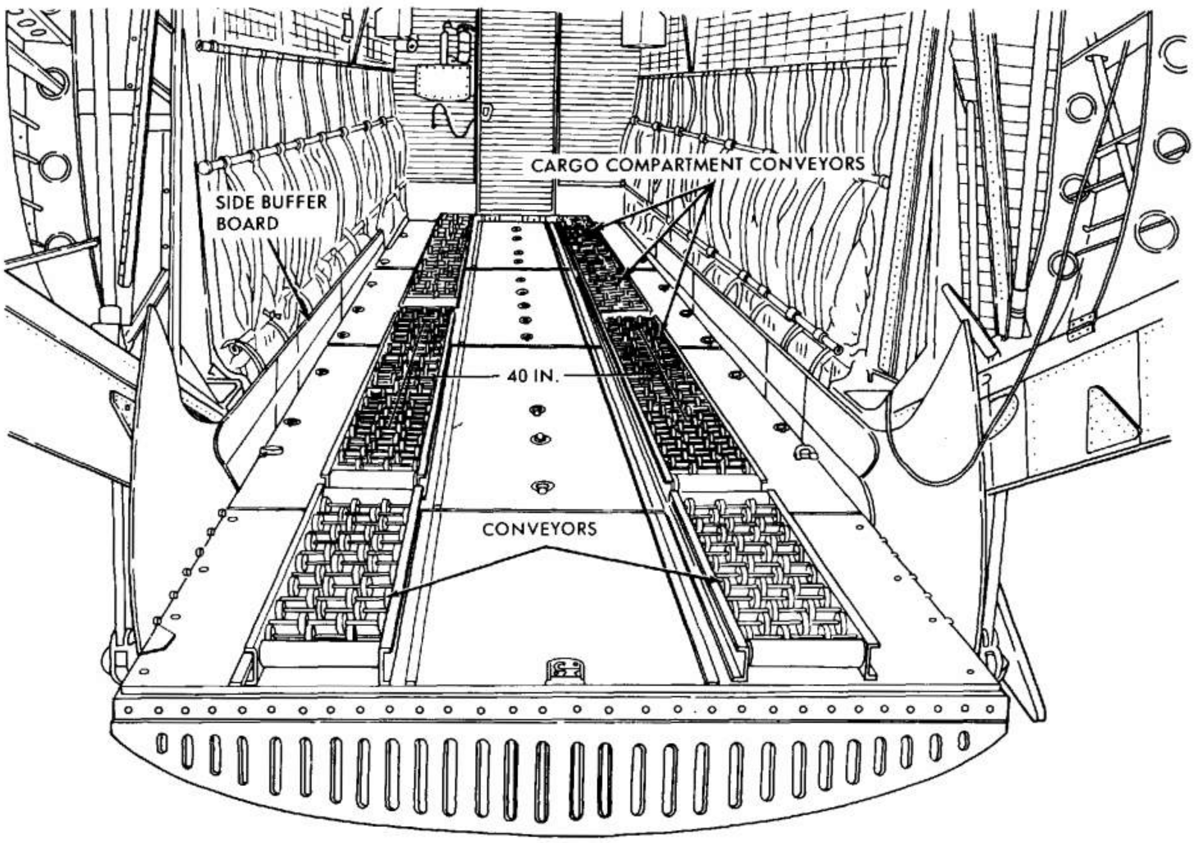


FIGURE 3–77. SKATE WHEEL AND BUFFER BOARD SYSTEM INSTALLED IN CV-2 AIRCRAFT

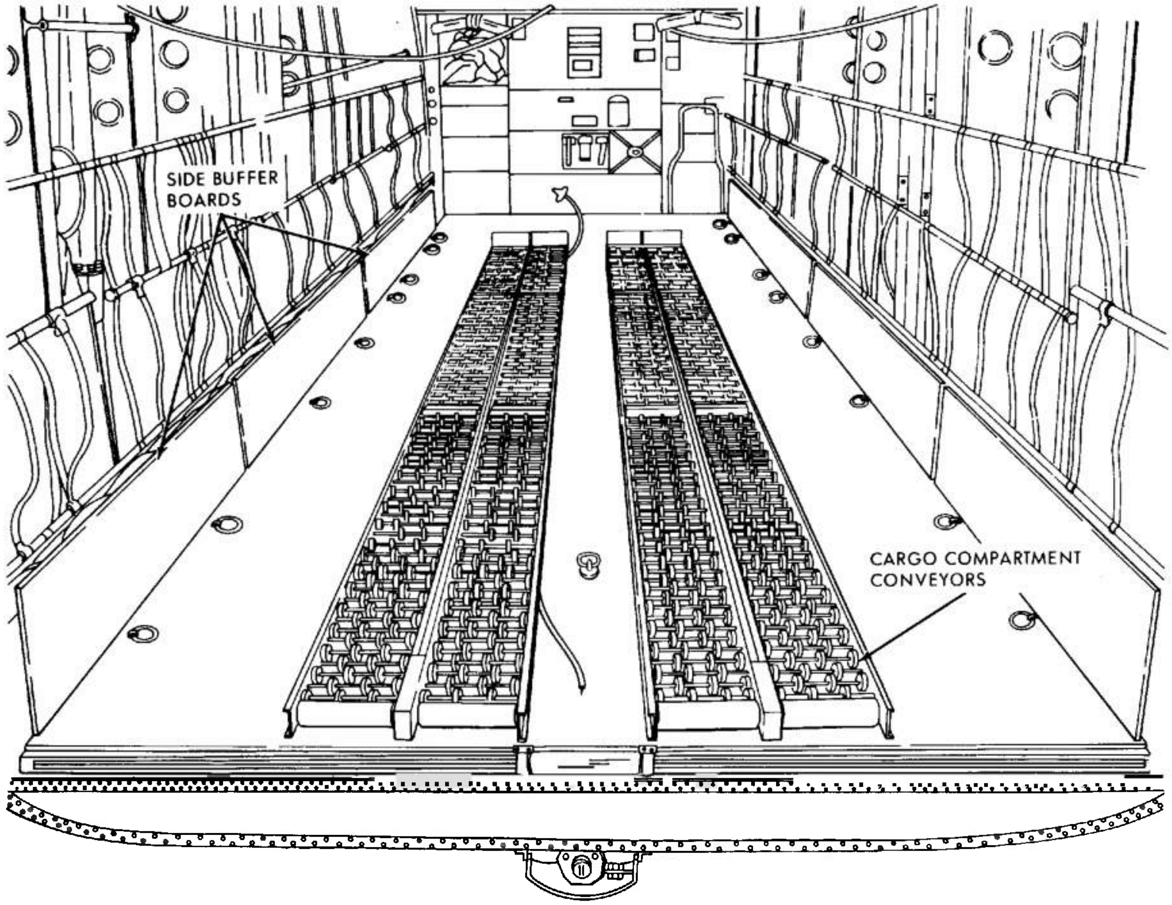


FIGURE 3–18. SKATE WHEEL AND BUFFER BOARD SYSTEM INSTALLED IN C-119 AIRCRAFT (DOUBLE ROW INSTALLED FOR AIRDROP OF A-22 CONTAINERS)

buffer boards may be installed before the aircraft is loaded; otherwise, they are positioned after the platforms are in place. Two ramp buffer plates on the CV-2 aircraft protect the ramp support arms. Side buffer boards for the C-119 aircraft are provided with hooks for securing them to the lower troop seat rail. The CV-2 side buffer boards are secured to the sides of the aircraft with screws and nuts.

Procedures for installing the skate wheel and buffer boards in C-119 aircraft are contained in T.O. 1C-119B-9. Procedures for installing skate wheel and buffer boards in CV-2 aircraft are contained in TM 10-500-5[16].

3–9.1 ADVANTAGES AND DISADVANTAGES

a. The advantages of the skate wheel and buffer board system are economy, easy installation and removal, and the capability of the conveyors to be adjusted to conform to the width of the cargo.

b. The disadvantage is danger to personnel. In this system, rigged loads must be secured with tiedown devices to the aircraft floor to provide the inflight restraint criteria. These restraint devices must be manually detached prior to airdrop.

3–9.2 RESTRAINT CRITERIA FOR TIEDOWN. When platforms must resist the extraction force, and when the extraction force is applied to the load, the loads shall be restrained to the platform in all directions with minimum load factors of 2 g's. For gravity ejections, the load shall be restrained to the platform with a minimum load factor of 1 g in all directions.

Rigged platforms shall be restrained to the aircraft floor with tiedown devices to the following criteria:

Forward	Lateral	Aft	Up
4.0 g	1.5 g	1.5 g	2.0 g

3—9.3 TIEDOWN PROVISIONS. Tiedown provisions utilized in the skate wheel and buffer board system are the restraint devices provided with the aircraft and the tiedown rings in the aircraft in which the system is used.

3—10 MONORAIL SYSTEM

Rapid dispersal of supplies and equipment can be accomplished through the monorail door by the overhead monorail system, Military Specification MIL-A-9153A, installed in the C-119 aircraft. The monorail system consists of 20 trolleys suspended from an overhead monorail, an electrically driven drum and cable, bundle guides, an anchor cable, and a trolley actuating system (Fig. 3—19). The trolleys are moved along the overhead monorail by the motor-driven cable. When the trolley reaches the release point, triggers operate a latch to release the bundles through the monorail door. Up to twenty 500-pound bundles can be released in a period of 7 to 8 seconds. For bundle size limitations, refer to par. 4—28.1.

In addition to dispersing bundles through the monorail door, the monorail system on the C-119 is used to provide a positive extraction force for airdrop of A-22 containers from the aft end of the aircraft. This method of extracting A-22 containers is called the Sling Shot Aerial Delivery System[17]. It incorporates a continuous cable and sling arrangement attached to the overhead monorail. The cables extend from the No. 20 trolley on the monorail to pulleys located aft of the load on each side of the cargo compartment. The two cables are joined together around the front of the load by cotton webs. The load is restrained from forward and aft movement by 10,000-pound capacity tiedown chains during takeoff and in flight. Just prior to airdrop, the load is restrained from forward movement by a steel plate.

The advantage of the Sling Shot Aerial Delivery System compared to the gravity method of extraction is that it provides a

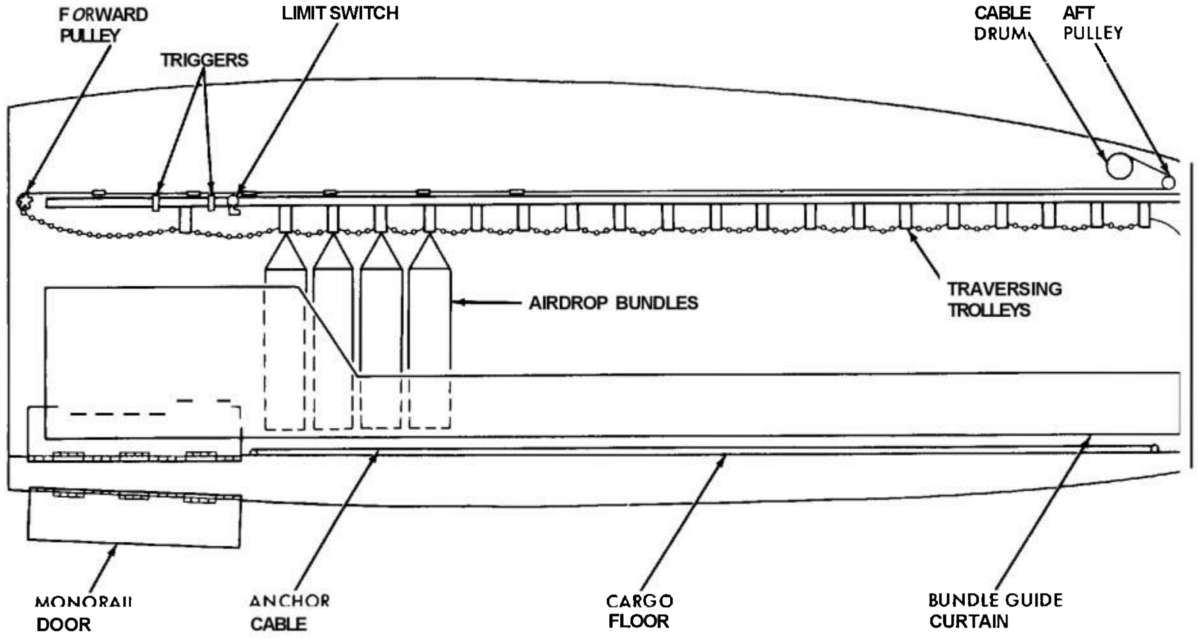


FIGURE 3—19. C-119 OVERHEAD MONORAIL SYSTEM

means of determining the exact time required to extract specific loads, which is necessary for an accurate Computed Air Release Point (CARP). When the gravity method is used for extracting loads, time required for loads to exit the aircraft sometimes varies to such an extent that an accurate CARP cannot be determined, resulting in delivery being accomplished outside the drop zone. (Each second the load remains in the aircraft after the CARP causes additional errors of approximately 225 feet.)

3—11 DUAL-RAIL SYSTEMS

The dual-rail cargo handling system (463L) provides the capability to safely handle equipment and supplies for aerial delivery and to expedite the handling of palletized cargo for terminal-to-terminal operations. The dual-rail system is basically a system of roller conveyors with additional features for restraint and release of cargo. It facilitates loading, securing, and parachute-extracted unloading of prepared loads. These loads are locked and released automatically by remote controls, thus enabling an operator to engage or disengage the locking mechanisms without placing himself in an unsafe position. Dual-rail systems are used in C-130, C-141, and CV-7A aircraft.

Airdrop platforms to be used with dual-rail systems shall be configured to fully utilize the dual-rail rollers. Figure 3—20 provides information as to the configuration and mating clearances of the restraint rail lip and the pallet/platform lip.

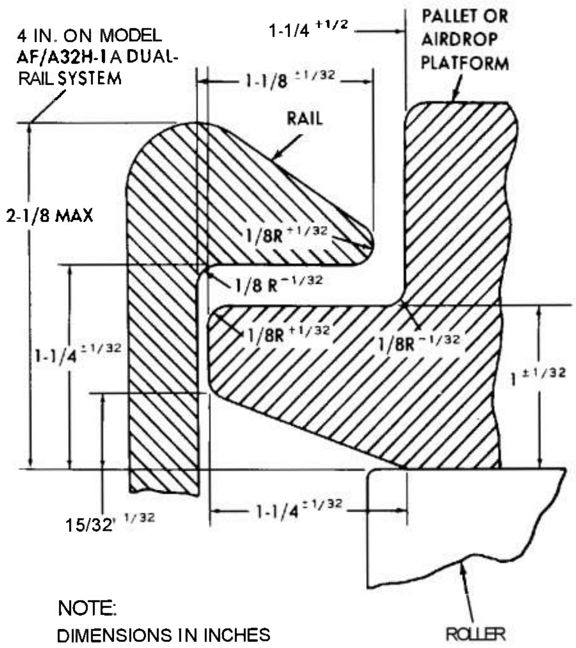


FIGURE 3-20. DETAILS OF RESTRAINT RAIL LIP AND PALLET OR PLATFORM LIP

3—11.1 MODEL AF/A32H-1A DUAL-RAIL SYSTEM.

The model AF/A32H-1A is an aircraft kit installed in C-130 aircraft to facilitate the handling of cargo pallets or airdrop platforms with widths of either 88 or 108 inches (Fig. 3—21). Type HCU-6/E and HCU-10/C pallets and modular airdrop platforms with type I or type II side rails can be used with this system. If the maximum allowable cargo weight is not exceeded, up to five loaded pallets or platforms can be loaded onto the conveyor section.

The model AF/A32H-1A dual-rail system consists of 10 conveyor frame assemblies, 14 intermediate conveyor frame assemblies, and 2 extension rails (Fig. 3—22). The conveyor frame assemblies are mounted on both outboard sides of the aircraft cargo floor and ramp. The extension rails are mounted on the cargo floor and bridge the cargo floor conveyor frame assemblies to the ramp conveyors. The intermediate conveyors are mounted on the cargo floor and ramp and are centered between the conveyor frame assemblies. Vertical and lateral restraint of platforms and 463L-type pallets are provided by the conveyor frame assembly rails. Rollers in the conveyor frame assemblies provide vertical support for the loaded pallets or platforms. Forward and aft restraint are provided by mechanical locks in the conveyor frame assemblies. Two sets of controls actuate the locking and release mechanisms. One set of controls actuates the left-hand mechanism, and one set actuates the right-hand mechanism.

3—11.1.1 Fixed-pin Latch Assemblies. There are five pairs of fixed-pin latch assemblies

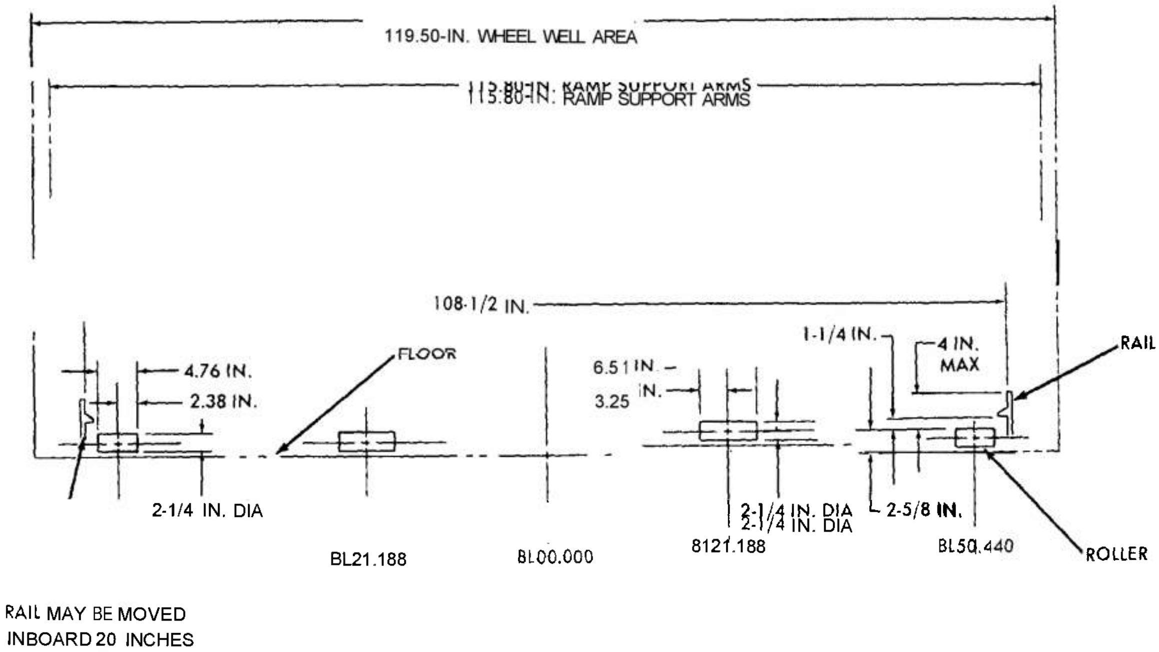


FIGURE 3-21. MODEL AF/A32H-1A DUAL-RAIL CARGO HANDLING SYSTEM (C-130)

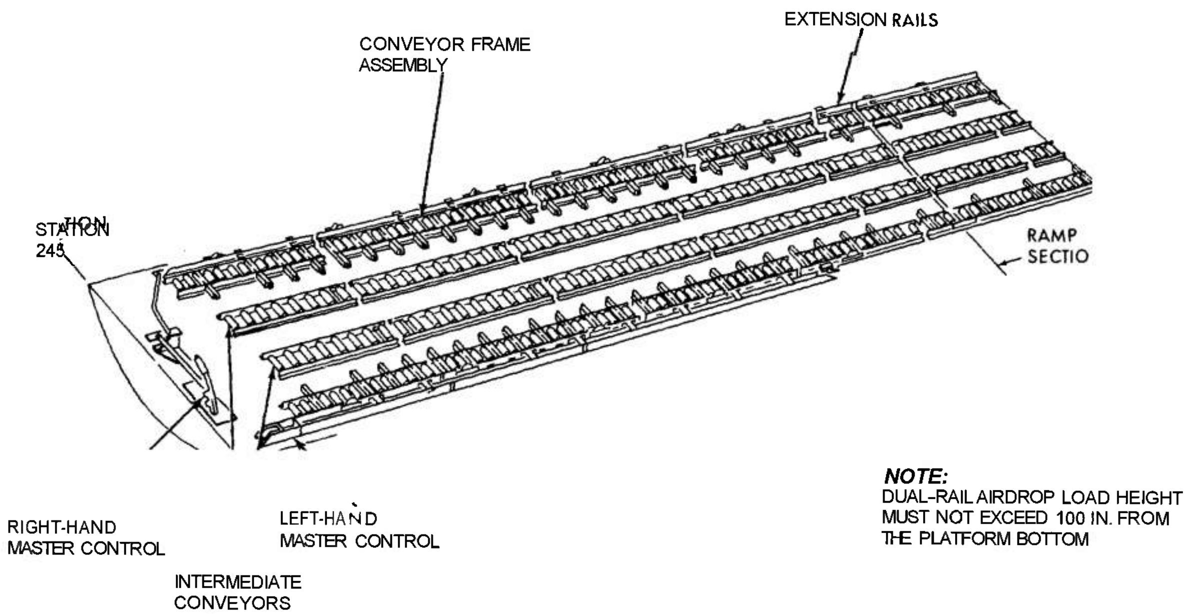


FIGURE 3-22. MODEL AF/A32H-1A DUAL-RAIL SYSTEM COMPONENTS

(Fig. 3-23) mounted on the conveyor frame assemblies. The fixed-pin latches engage restraining pins on the modular platforms which prevent fore-and-aft movement. The left-hand latch assemblies provide both forward and aft restraint. The right-hand latch assemblies are mounted directly opposite, and provide only forward restraint. The right-hand latch assemblies supplement the restraining capability of the left-hand latch assemblies to prevent forward movement of platforms under abnormal conditions (such

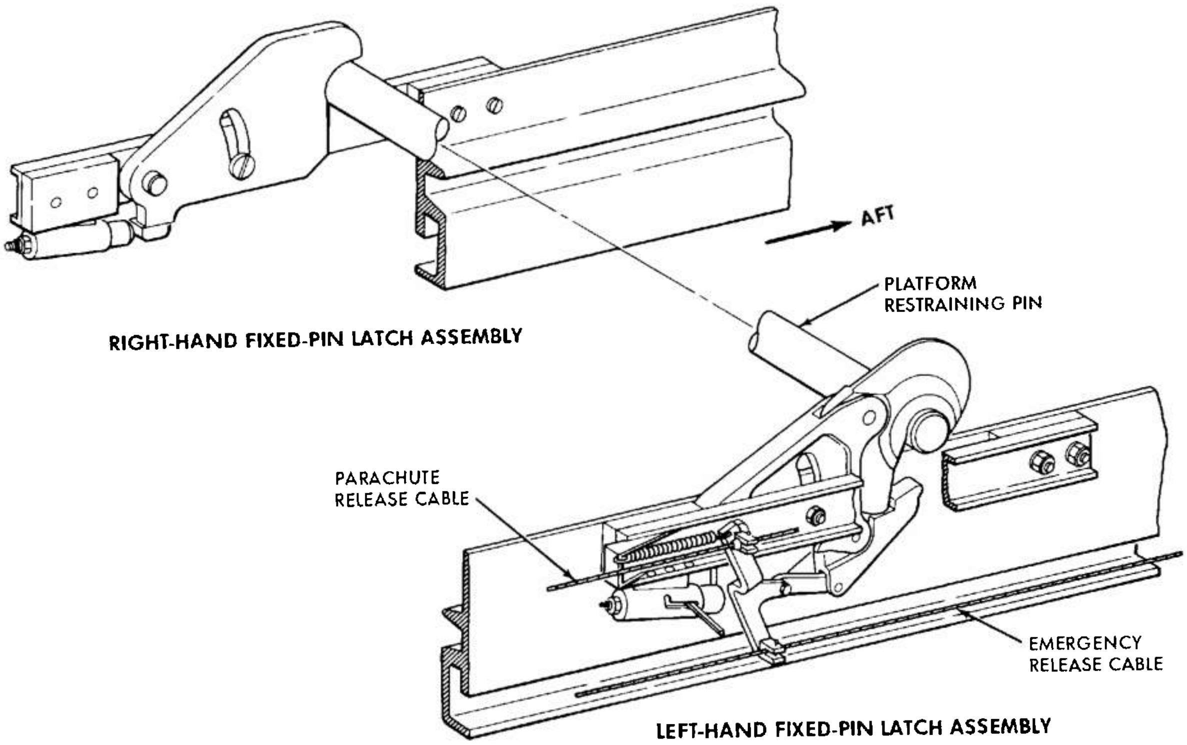


FIGURE 3-23. FIXED-PIN LATCH ASSEMBLIES

as a forced landing). The fixed-pin latch assemblies are manually raised to accept and engage the platform restraining pins as each platform is loaded into the aircraft. During airdrop, the latches are unlocked mechanically by the first extraction parachute which pulls a cable to release the latch hook retainers. With the hook retainers released, aft movement of the platform rotates the hooks upward to release each platform. All left-hand fixed-pin latches are released simultaneously so that platforms are only minimally restrained by breakcords until their respective extraction parachutes deploy and inflate to a force level exceeding the breakcord strength (par. 3–25.2.1). The raised fixed-pin latch assemblies are then depressed in sequence by the platform restraining pin of each platform as it moves aft. The fixed-pin latch assemblies will eventually be obsoleted by the detent latch assemblies.

3–1 1.1.2 Detent latch Assemblies. Ten variable restraint detent latches are mounted on the right-hand rails. Each latch has a constant forward restraining force of 20,000 pounds and a variable aft restraining force of 250 to 4000 pounds. The latch detents are spring-loaded. When the latches are placed in the engaged position, the detent projects through the rail and mates with the pallet or platform indent. The pallet or platform is then restrained in the aft direction an amount equal to the force preset into the spring. The detents will disengage and remain disengaged when the preset force is overcome by an aft-directed force (extraction parachute) on the platform.

Ten detent latches are also mounted on the left-hand rails, directly opposite the right-hand detent latches. Each left-hand detent latch, when engaged, is capable of providing a restraining force of 20,000 pounds forward and 10,000 pounds aft. When unlocked, latch detents will retract into the rail due to aft movement of the platform.

With this type of restraint system, it is possible to design within the requirements of both airdropping and logistical roles, with particular references to g-loading factors.

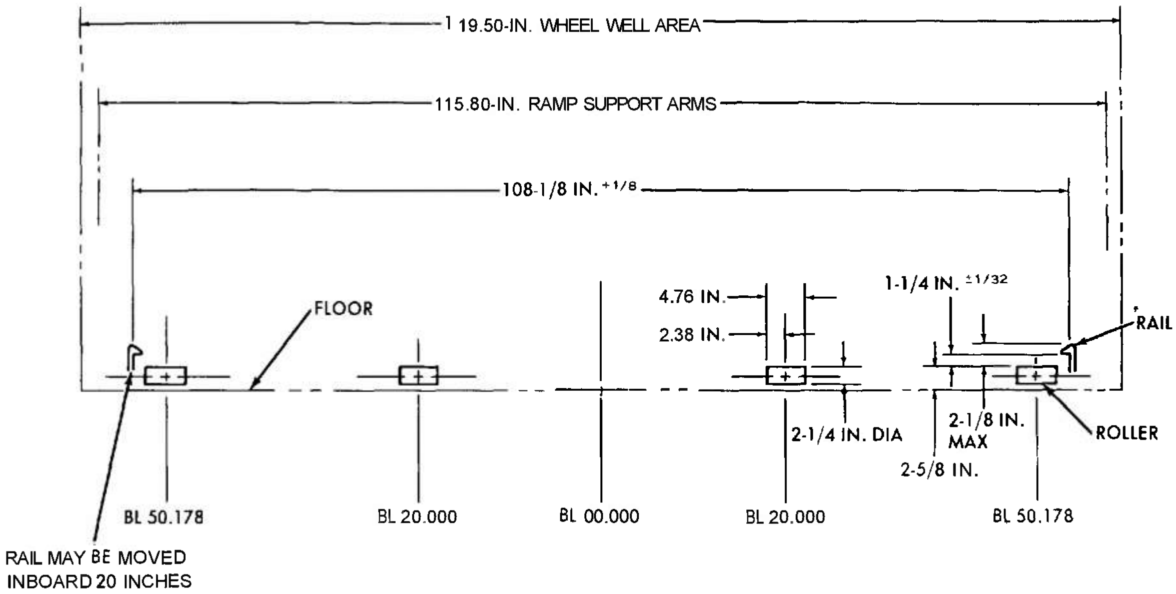


FIGURE 3–24. MODEL A/A32H-4 DUAL-RAIL CARGO HANDLING SYSTEM (C-130)

3–11.2 MODEL A/A32H-4 DUAL-RAIL SYSTEM. The model A/A32H-4 dual-rail system (Fig. 3—24) is similar to the model AF/A32H-1A dual rail system described in paragraph 3—11.1. The model A/A32H-4 dual-rail system is installed in C-130 aircraft and consists of 12 outboard conveyor frame assemblies, 17 intermediate conveyor frame assemblies, and 2 extension rail assemblies. There are 11 detent latch assemblies mounted on each side of the rail assemblies. This system does not incorporate fixed-pin latch assemblies for forward and aft restraint of loads. This system employs only the indent/detent restraint system where the detent latch assemblies engage with series of notches or indents on each side of the pallet or platform. Type HCU-6/E and HCU-10/C pallets and modular airdrop platforms with type II side rails are used for cargo loads with this system.

3—11.3 C-141 INTEGRAL SUBSYSTEM. The integral subsystem used in the C-141 aircraft consists of roller conveyor sections and dual restraint rails with indent/detent restraint system and remote controls (Fig. 3—25). The conveyor sections are turned over and locked into recesses in the cargo compartment floor when not in use. The restraint rails forward of the troop doors are folded up under the side walkways when not in use, and the remaining rails are stowed as loose equipment. This system uses the type HCU-6/E pallets and modular airdrop platforms with type II side rails for cargo loads.

3—11.4 CV-7A INTEGRAL SUBSYSTEM. The integral subsystem used in the CV-7A aircraft consists of stowable roller conveyors and a side guidance and restraint rail system to permit the use of palletized cargo. The CV-7A integral subsystem is functionally the same as the C-141 integral subsystem described in par. 3—11.3. Restraint guide rails on each side of the cargo floor provide vertical and lateral restraint for modular platforms during takeoff, flight, landing, and ejection from the aircraft. The rail assembly extends lengthwise on either side of the cargo compartment for a length of 30 feet, 10 inches. It also extends the full length of the ramp. Fore-and-aft restraint is provided by locking mechanisms integral with the guide rails. The control system is capable of sequentially disengaging the fixed restraint locks, starting with the aftermost lock, and of sequentially engaging the fixed restraint locks, starting with the forwardmost lock. The CV-7A integral subsystem is restricted to a maximum nominal platform width of 88 inches.

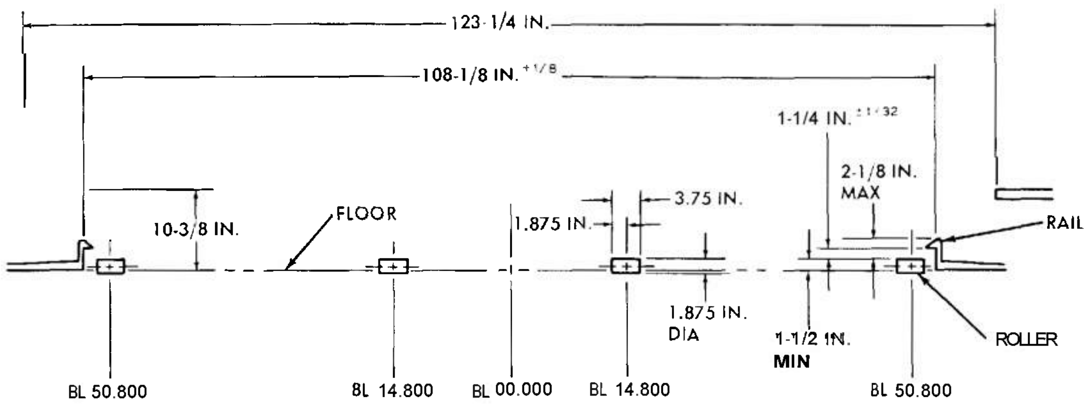


FIGURE 3–25. INTEGRAL SUBSYSTEM CARGO HANDLING SYSTEM (C-141)

3–11.5 VARIATION IN DUAL-RAIL SYSTEMS. Particular note should be taken of the fact that while dual-rail systems used for airdrop are functionally similar, detailed differences occur among the various types of aircraft. These differences cannot be neglected in the design of compatible airdrop hardware. Variations in roller strength, placement and size, and differences in rail profile configurations must be carefully noted in the establishment of design criteria for mating hardware.

3–12 PENDULUM RELEASE

The pendulum release is used to release the extraction parachute. A typical pendulum release consists of a bracket in which a bomb rack is mounted, a pivot arm, a manual cocking cable for the bomb rack, an electric release system which is used for normal release of the bomb rack, and a manual emergency release cable (Fig. 3–26). The device is attached to overhead frame members above the cargo floor and is on the centerline of the aircraft.

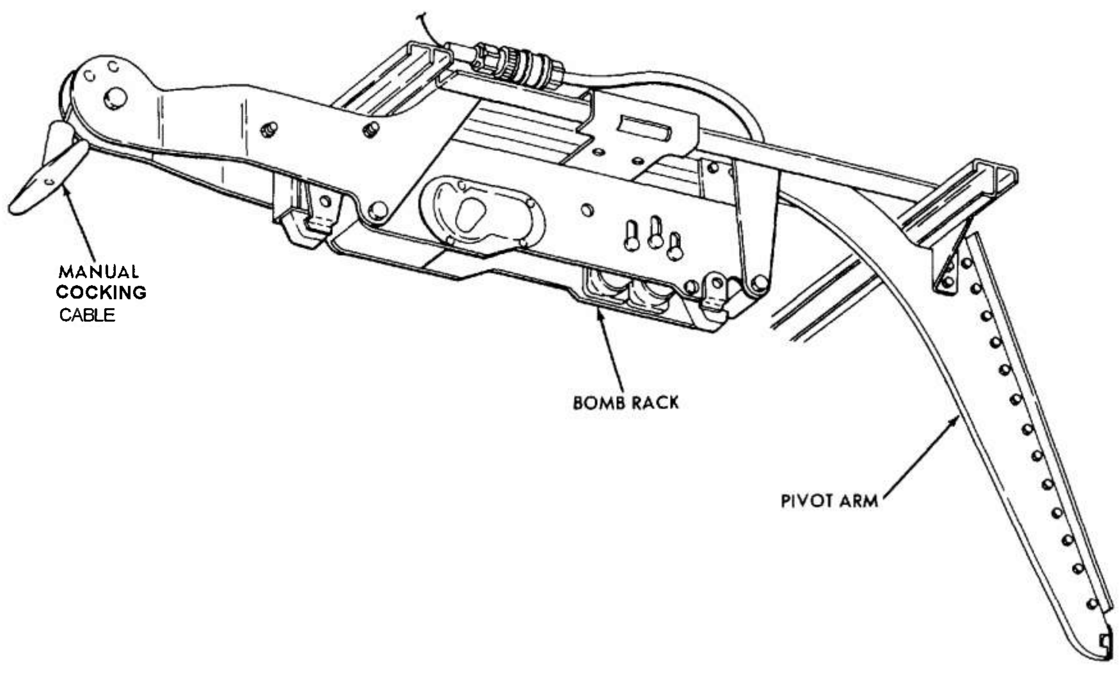


FIGURE 3–26. TYPICAL PENDULUM RELEASE

An extraction parachute (par. 3—16) is retained in a horizontal position by the pendulum release, engaging V-rings secured to the deployment bag (Fig. 3—27). A short pendulum line runs from the deployment bag to a notch in the pivot arm. When the bomb rack is actuated, the parachute falls as a pendulum in an arc around the end of the pivot arm until a satisfactory release-attitude is reached for deployment. At this point, the loop in the pendulum line slips from the notch and the parachute is then free to be carried aft through the cargo door and is subsequently deployed by the airstream.

3—13 ANCHOR LINE CABLES

Anchor line cables provide an attachment point for the static lines. Two static lines are required for the C-119, C-123, C-130, and C-141 aircraft. The CV-2B uses one static line. The anchor line cable must be kept free from obstructions between the static line connection and the aft cable support. The static line must be connected in a manner to move freely on the anchor line cable within a 30-degree angle of pull. As the load is pulled from the aircraft by the extraction parachute, the static line moves along the anchor line cable until it reaches the cable stop near the aft cable support. Cotton reinforcing tape, securing the static line to the load, prevents drag forces created by movement of the static line along the anchor line cable from being transmitted to the static line knife. When the static line reaches the cable stop, the tape is broken and the static line knife cuts the extraction line connector strap. This transfers the extraction force to the deployment line of the recovery parachute(s). All static lines shall have a maximum breaking strength of 2900 pounds and a trailing length no greater than 17 feet. All hardware on a trailing static line located more than 2 feet aft of the attachment fitting to the anchor line cable shall be padded to protect the airframe from possible damage.

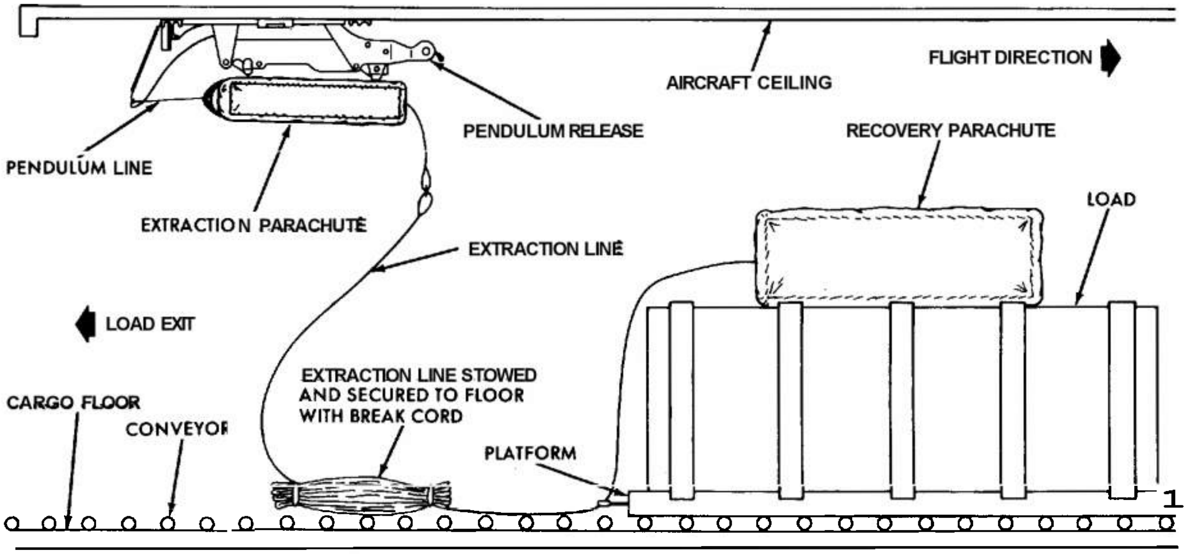


FIGURE 3–27. EXTRACTION PARACHUTE INSTALLED IN PENDULUM RELEASE

SECTION III

AIRDROP EQUIPMENT GROUP

3—14 GENERAL

The primary objective of an airdrop system is to achieve the capability of delivering a variety of vehicles, weapons, heavy cargo, and miscellaneous supplies to any strategic locality in such a manner that they will be usable within a minimum amount of time and with minimum hazard to personnel involved. Present airdrop systems achieve this capability by employing airdrop equipment contained in the following groups.

a. Recovery Parachute and Disconnect Group. The equipment in this group must be capable of producing the proper rate of descent. Equipment is also provided in this group for releasing the recovery parachute upon ground contact to prevent overturning or dragging of the load during high ground-wind conditions.

b. Extraction and Force Transfer Group. The equipment in this group must be capable of producing the required cargo extraction force and transferring this force to deployment of the recovery parachute(s).

c. Restraint Group. The equipment in this group must provide longitudinal, lateral, and vertical restraint for the load based on the aircraft load factors. It also restrains the airdrop item to the platform during descent and impact.

d. Platform Group. This equipment serves as a base for rigging the load and must provide support for the load while it is in the aircraft, during descent, and upon landing.

e. . Container Group. The equipment in this group provides a means of dropping small unit loads (100-2200 pounds) of equipment and supplies by parachute from aircraft in flight.

f. Energy Dissipation Group. The equipment in this group must provide ground-shock attenuation to soften the impact of the load and prevent damage due to ground impact shock.

3—15 RECOVERY PARACHUTE AND DISCONNECT GROUP

3—15.1 RECOVERY PARACHUTES. cargo recovery parachutes are used in low-velocity airdrop to retard the rate of descent of the airdrop load to a level which will permit landing of the load without damage. Cargo parachutes may be used singly and in clusters to obtain similar rates of descent for a large range of airdrop item weights. When used in clusters, the risers of the parachute are extended by means of slings or riser extensions (par. 3—24.2).

3—15.1.1 Characteristics of Standard Types. The flat circular canopy (Fig. 3—28) and the shaped-gore canopy (Fig. 3—29) are the two main types of parachute canopies used in airdrop recovery systems. Both canopy

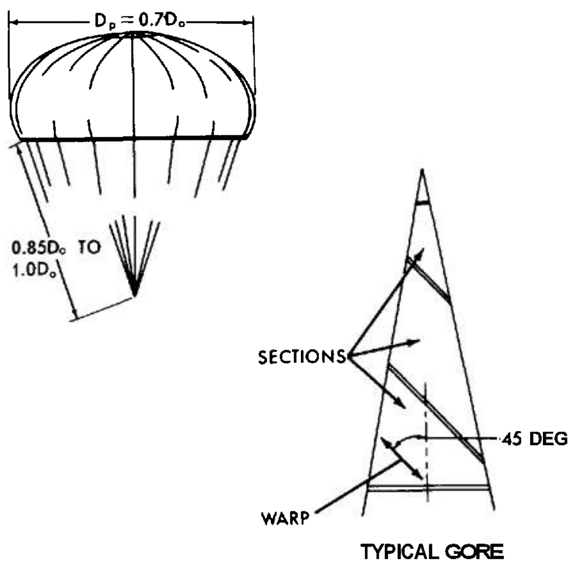


FIGURE 3–28. FLAT CIRCULAR CANOPY

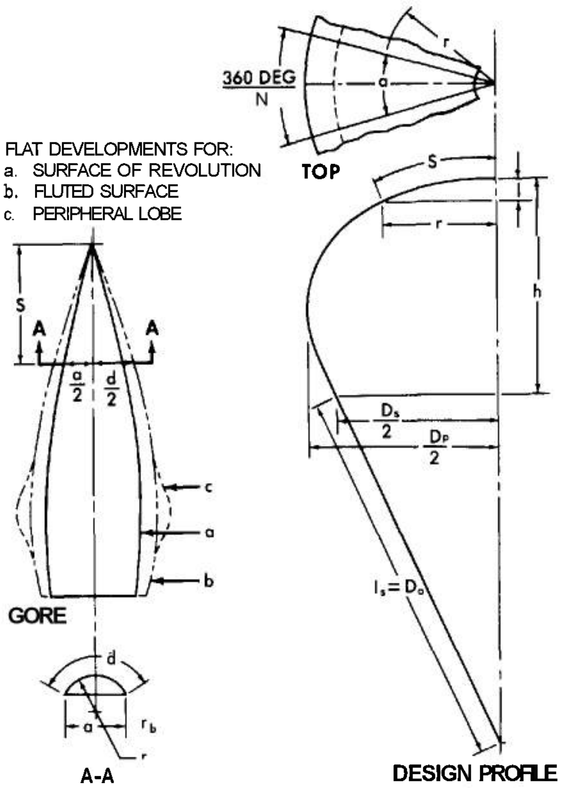


FIGURE 3–29. SHAPED-CORE CANOPY

types are reliable for airdrop recovery operations and have similar performance characteristics when a solid textile material is used in canopy construction as shown in Table 3–2. Characteristics of standard cargo recovery parachutes using these canopies are shown in Table 3–3.

3–15.1.2 Deployment Systems. Cargo canopies for 100- to 500-pound loads are packed in the standard envelope pack. This pack is attached to the load and does not assist deployment. The static line is attached directly to the apex of the canopy with a breakcord of predetermined size placed between the apex and the free end of the static line. The G-13 and the T-7 (as converted for cargo) are most often used with this system.

For cargo loads between 700 and 2200 pounds, utilizing an A-22 container and a G-12D parachute, a nylon deployment bag is used. Deployment is initiated by a 68-inch octagonal pilot chute, which is deployed by a static line attached to the aircraft.

For cargo loads between 2200 and 35,000 pounds, clusters of the G-12D or G-11A parachutes are used. Both of theee parachutes are deployed by the bag-type deployment method.

3–15.1.3 Parachute Clustering. For the delivery or final recovery of heavy loads or vehicles, it is advisable to arrange moderately sized canopies in a cluster, rather than increase the diameter of a single canopy to the required dimension.

The drag efficiency of solid cloth canopies arranged in a cluster decreases with the number of canopies used. The reason for this decrease may be seen in the

TABLE 3–2. TYPICAL PERFORMANCE CHARACTERISTICS OF SOLID TEXTILE PARACHUTE CANOPIES[18]

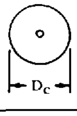
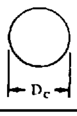
CANOPY TYPE	CONSTRUCTED SHAPE		DIAMETER RATIOS		DRAG COEFFICIENT		OPENING SHOCK FACTOR (INFINITE MASS)	STABILITY	
	PLAN VIEW	PROFILE VIEW	D_p/D_c	D_o/D_c	RANGE	AVERAGE (PRELIM DESIGN)		$\partial C_M/\partial \alpha$ (ABOUT 0 DEG ANGLE OF ATTACK)	AVERAGE ANGLE OF OSC (FREE DESCENT)
FLAT CIRCULAR		—	-0.70	1.00	C_{D_o} 0.65 TO 0.90	C_{D_o} 0.75	<2.0	POSITIVE	±30 DEG
SHAPED-GORE			-1.0	1.41	C_{D_o} 0.65 TO 0.85	C_{D_o} 0.75	-1.8	POSITIVE	±25 DEG

TABLE 3–3. CHARACTERISTICS OF STANDARD C

ABBREVIATED NOMENCLATURE	WEIGHT* (lb)	MAXIMUM LOAD LIMIT (lb)	METHOD OF DEPLOYMENT	CANOPY			SUSPENSION LINES			DEPLOYMENT BAG AND/OR PACK
				TYPE	NOMINAL DIAMETER (ft)	TYPE OF MATERIAL	NUMBER	LENGTH (ft and in.)	TYPE OF MATERIAL	
G-1 and G-1A	25	300	Static Line	Flat Circular	24	4.25 oz Rayon Cloth	24	15 ft 0 in.	1/2-inch Type II Rayon Tape	Pack
T-7A Converted	20	300	Static Line	Flat Circular	24	1.6 oz Nylon Cloth	24	16 ft 10 in.	Type III Nylon Cord	Pack
T-7 Converted	25	500	Static Line	Flat Circular	28	1.6 oz Nylon Cloth	28	22 ft 10 in.	Type III Nylon Cord	Pack
G-13	45	500	Static Line	Parabolic Shaped-Gore	Nominal– 32.4 Skirt – 24.25	4.25 oz Type II Cotton Muslin	20	30 ft 0 in.	Type I Braided Rayon Cord	Pack
G-12C	128	2200	Pilot Chute	Flat Circular	64	2.25 oz Dobby Weave Nylon Cloth	64	51 ft 0 in.	Type IV Braided Nylon Cord	Pack
G-12D	128	2200	Pilot Chute or Extraction Parachute	Flat Circular	64	2.25 oz Dobby Weave Nylon Cloth	64	51 ft 0 in.	Type IV Braided Nylon Cord	Deployment Bag
G-11	250	3500	Extraction Parachute	Flat Circular	100	1.6 oz Nylon Cloth	120	60 ft 0 in.	Type III Nylon Cord	Deployment Bag
G-11A	250	3500	Extraction Parachute	Flat Circular	100	1.6 oz Nylon Cloth	120	35 ft 0 in.	Nylon Cord	Deployment Bag

*Approximate packed weight of entire parachute assembly altered flow field around individual canopies. This flow, on the other hand, improves static stability of the cluster configuration. A depiction of the drag coefficient versus the number of canopies in a cluster is shown in Fig. 3—30.

For canopies with geometric porosity, such as ribbon or ring-slot types, the decrease in canopy drag efficiency with number of canopies in a cluster is negligibly small. Here the flow field around the individual canopies is not significantly altered or influenced by other canopies in the cluster. In general, statically stable canopies, when clustered, do not change their drag efficiency significantly. Statically unstable canopies, however, show a marked decrease in drag efficiency with number of canopies in a cluster. The magnitude of decrease in drag efficiency is a function of the static-stability characteristic of the individual canopy.

3—15.1.4 Canopy Reefing. Canopy reefing is a method by which the projected diameter of a canopy is reduced temporarily or permanently — through the use of auxiliary lines and mechanical accessories — resulting in a reduction of the drag area of the canopy. Reefing — as a method of drag area control — may be applied for the following purposes:

a. To limit canopy-opening force to a predetermined value, through successive steps of opening at predetermined intervals, called disreefing, or through controlled continuous disreefing.

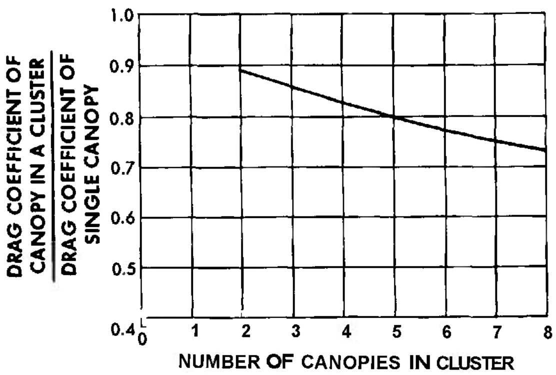


FIGURE 3-30. AVERAGE DECREASING DRAG COEFFICIENT RATIO (CLUSTERED)

b. To attain a preliminary high rate of descent by extensive reefing to achieve accurate drops from high altitudes.

c. To increase the stability of a canopy — either temporarily for a particular application — or to adapt an available parachute to an application that requires increased stability.

d. To minimize nonuniformity of inflation time during the operation of clusters of parachutes.

Reefing is not generally used in most cargo parachute operations because canopies are designed to withstand opening-shock forces at normal deployment velocities. At present, reefing is confined mostly to clusters of large parachute canopies, where the reefing insures that all canopies reach the same stage of inflation at the same time. Disreefing of the canopies then results in an even deployment and minimizes canopy damage.

3—15.1.5 Reefing Methods.

3—15.1.5.1 **System I.** The most frequently used reefing method, called skirt-reefing (Fig. 3—31), is recommended where one-step disreefing or a short reefing period is desired. In this method, a line — called the reefing line — is placed around the skirt of the canopy. The reefing line is guided in small metal reefing rings, which are fastened on the skirt on the inside of the canopy at each suspension line. The reefing

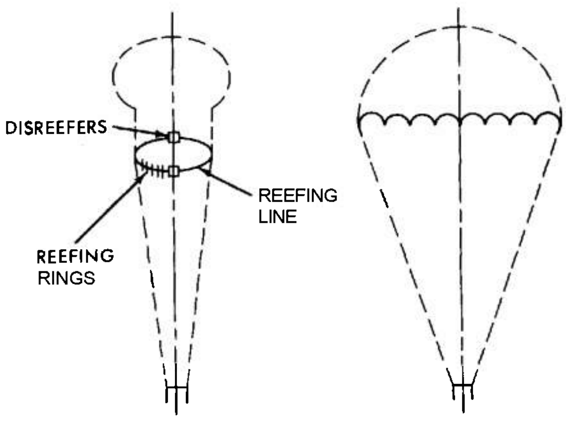


FIGURE 3-31. REEFING SYSTEM I

line is fastened at both ends and is cut with a disreefing device after a certain delay period. At least two disreefing devices are recommended for reliability and quicker opening of the parachutes.

3—15.1.5.2 System II. For longer or variable periods, reefing system II (Fig. **3—32)** is advisable. In this method, the reefing line is guided through reefing rings inside the canopy skirt. It consists of two separate lines leading out from the skirt at point **A** (Fig. **3—32)** and connected with the control line at point B. By retraction of the control line, the canopy is reefed, and by extension of the control line, it is disreefed. Application of this system for continuous disreefing is feasible and depends primarily on the design and operation of the disreefing device. The control line is connected with the disreefing device at the suspension-line connecting point, to the suspended load, or in the aircraft. This method is particularly adaptable to designs in which disreefing must be a function of several variables and require a large and complicated actuating device.

3—15.1.5.3 System III. The schematic outline of this method is shown in Fig. **3—33.** View (C) illustrates the canopy at various stages of reefing. The canopy is reefed by pulling the vent down inside the canopy, as opposed to a skirt restriction method. The force required to pull the vent down amounts to approximately one-half the total force

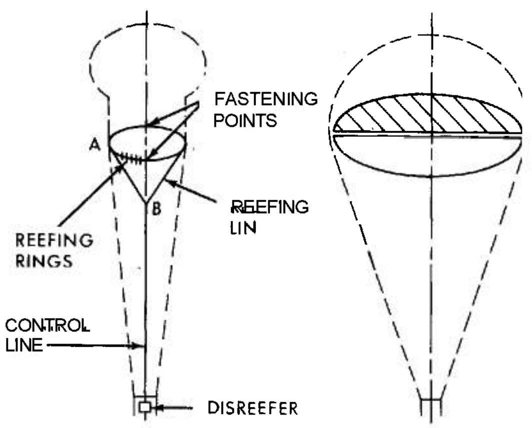


FIGURE 3-32. REEFING SYSTEM II

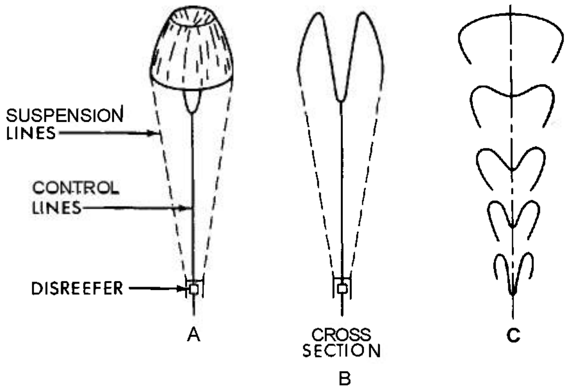


FIGURE 3-33. REEFING SYSTEM III

exerted on the canopy. A significant increase in drag, as shown in Fig. **3—34,** is produced by this method up to a control line movement of about **40** percent of the flat canopy diameter. At this point, this method begins to be effective for reducing the total drag force experienced by the canopy. A disadvantage of this reefing method is the high force in the control line and the large amount of reefing necessary to obtain a significant drag reduction.

3—15.1.6 Reefing Lines. In the design of a reefed canopy, the choice of the proper reefing line length is extremely important. The reefing line must also be designed to withstand maximum forces dependent upon the percentage of drag area of the canopy in the reefed condition $(C_D S)_R$ compared with its drag area in the fully inflated condition $(C_D S)_o$.

The forces in the control lines of a reefing system similar to system II were measured on a flat circular ribbon parachute 10 feet in diameter, towed behind an aircraft at **125** mph. The forces in the reefing line and the skirt-opening forces were calculated from the forces measured in the control line. These forces, as a function of reefing ratio $(C_D S)_R/(C_D S)_o$, are shown in Fig. **3—35.**

The permissible diameter and drag area of a skirt-reefed, flat circular canopy can be determined as the diameter of a reefing line, as in the following example:

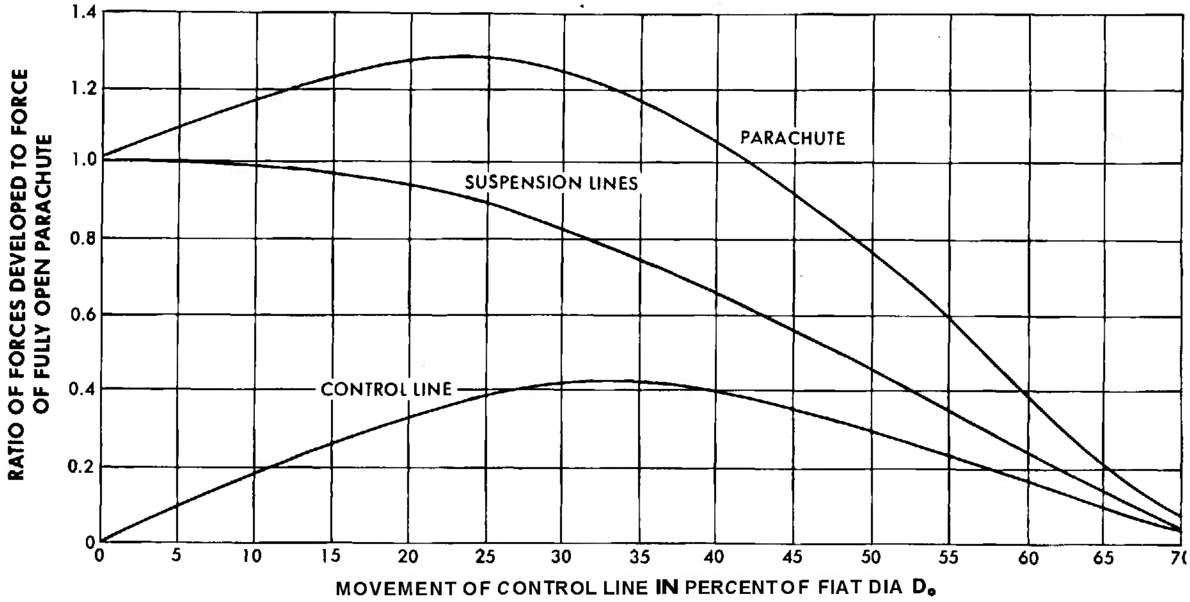


FIGURE 3-34. VENT REEFING FORCES IN THE PARACHUTE, SUSPENSION LINES, AND CONTROL LINE

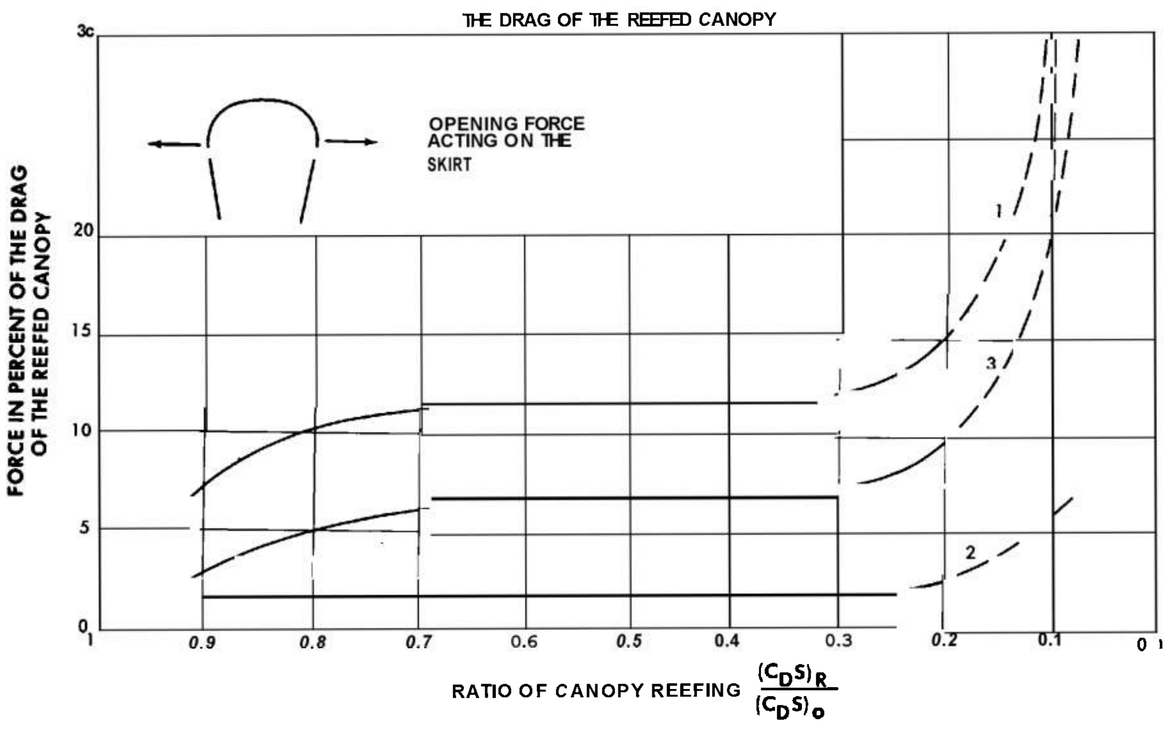


FIGURE 3-35. REEFING LINE, CONTROL LINE, AND SKIRT OPENING FORCES

C_{D_o} = drag coefficient based on total canopy surface area

D_o = nominal diameter of the unreefed canopy

$(C_DS)_o$ = drag area of the unreefed canopy (based on C_{D_o})

D_1 = theoretical diameter of the reefed canopy = $2\sqrt{\dfrac{(C_DS)_R}{\pi C_{D_o}}}$

D_{R_1} = skirt diameter of the reefed canopy

D_{R_o} = skirt diameter of the fully inflated canopy

$(C_DS)_R$ = drag area of the reefed canopy

N = number of gores

C = ratio of reefing-line diameter length to nominal diameter of unreefed canopy = D_{R_o}/D_o

6 = ratio of skirt diameters = D_{R_1}/D_{R_o}

a. If a canopy with a C_{D_o} = **0.47** of D_o = **20** ft, with N = 20 gores, and a drag area $(C_DS)_o$ = **148 sq** ft, has a permissible drag area reefed $(C_DS)_R$ = **16 sq** ft, the drag area ratio then = $\dfrac{(C_DS)_R}{(C_DS)_o} = \dfrac{16}{148}$ = **0.108.**

C = **0.61** for **20** gores as shown in Fig. **3—36,** and δ = **0.194** for a drag area ratio of **0.108** as shown in Fig. **3—37.** With these data, the diameter of the reefing line circle may be determined as follows:

$$D_{R_1} = D_o C \delta$$

$$D_{R_1} = 20 \times \mathbf{0.61} \times 0.19 = \mathbf{2.36}\text{ ft}$$

b. The theoretical diameter of the reefed canopy can also be calculated as follows:

$$D_1 = 2\sqrt{\frac{(C_DS)_R}{\pi C_{D_o}}} = 2\sqrt{\frac{16}{(\pi)(0.47)}} = 6.6\text{ ft}$$

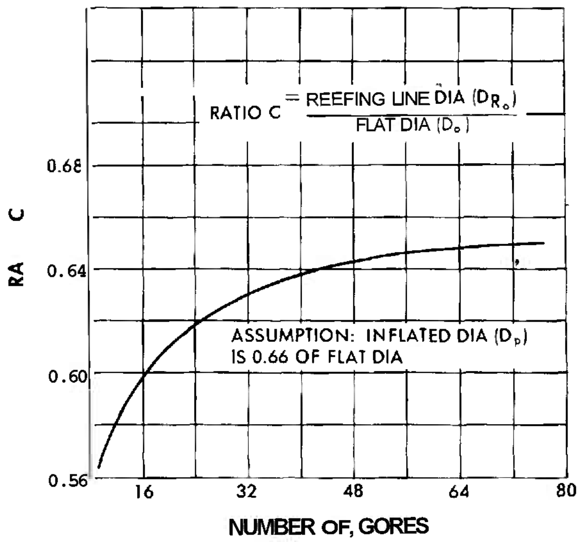


FIGURE 3-36. C VS NUMBER OF GORES

c. The data presented in Figs. **3—36** and **3—37** have been verified by tests and apply to all types of flat circular canopies. Tests have been made on reefed extended-skirt canopies to provide sufficient data to make similar plot of drag-area ratio versus reefing ratio for this type of canopy. These curves, plotted from empirical data, are shown in Fig. **3—38.**

3—15.1.7 Reefing Line Cutters. The current standard method of disreefing a parachute canopy, when skirt-reefing is used, is to cut the reefing line which is threaded through reefing rings around the skirt of the canopy. Pyrotechnic reefing line cutters are generally employed for this purpose.

Most reefing-line cutters in use today operate in the same basic manner. At the time during the deployment process at which the suspension lines are fully stretched and the force on the reefingline cutter arming lanyard, which is attached to the deployment bag, builds up to approximately **35** pounds, the arming lanyard is withdrawn from the cutter. This releases a firing pin, which strikes a primer cap, which in turn initiates a power-train time delay designed to burn for a predetermined number of seconds. After a delay interval, the

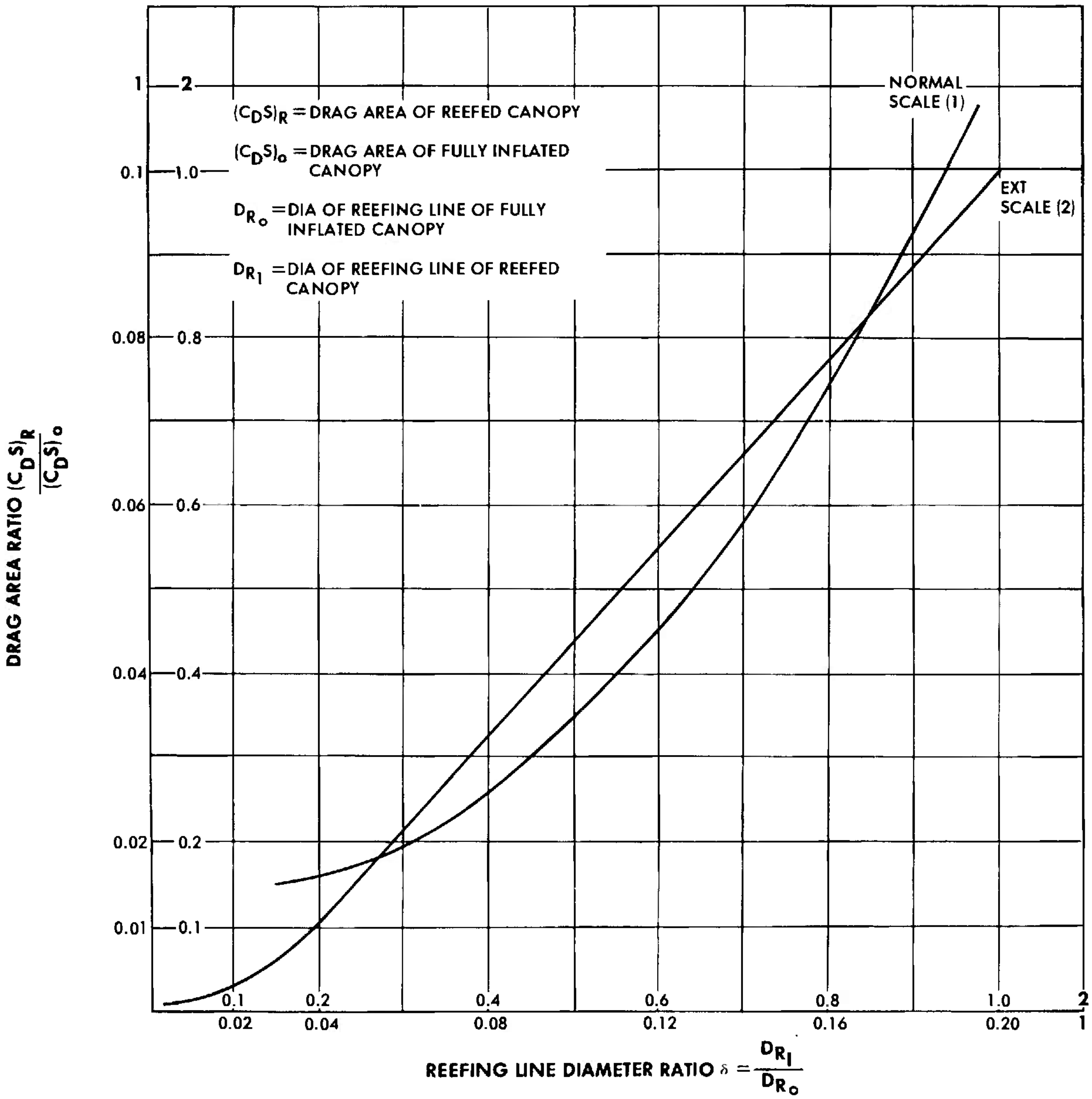


FIGURE 3-37. DRAG AREA RATIO VS REEFING LINE DIAMETER RATIO

final propellant is ignited, driving the piston-shaped cutter knife down the barrel, and severing the reefing line threaded through the holes near the end of the barrel.

3-15.1.7.1 Standard Types

a. The M21 reefing line cutter (Fig. 3-39) is the primary standard model used in Army applications and is designed to cut lines of up to 1000-pound tensile strength. This device has a time delay of 2 seconds and is not reusable.

b. Efforts to improve the action and reliability of reefing line cutters for cargo delivery systems and drone parachute recovery systems have resulted in the development of the M9 through M13 series cutters. These are designed to operate during the higher opening shock encountered in high speed deployment. The M9

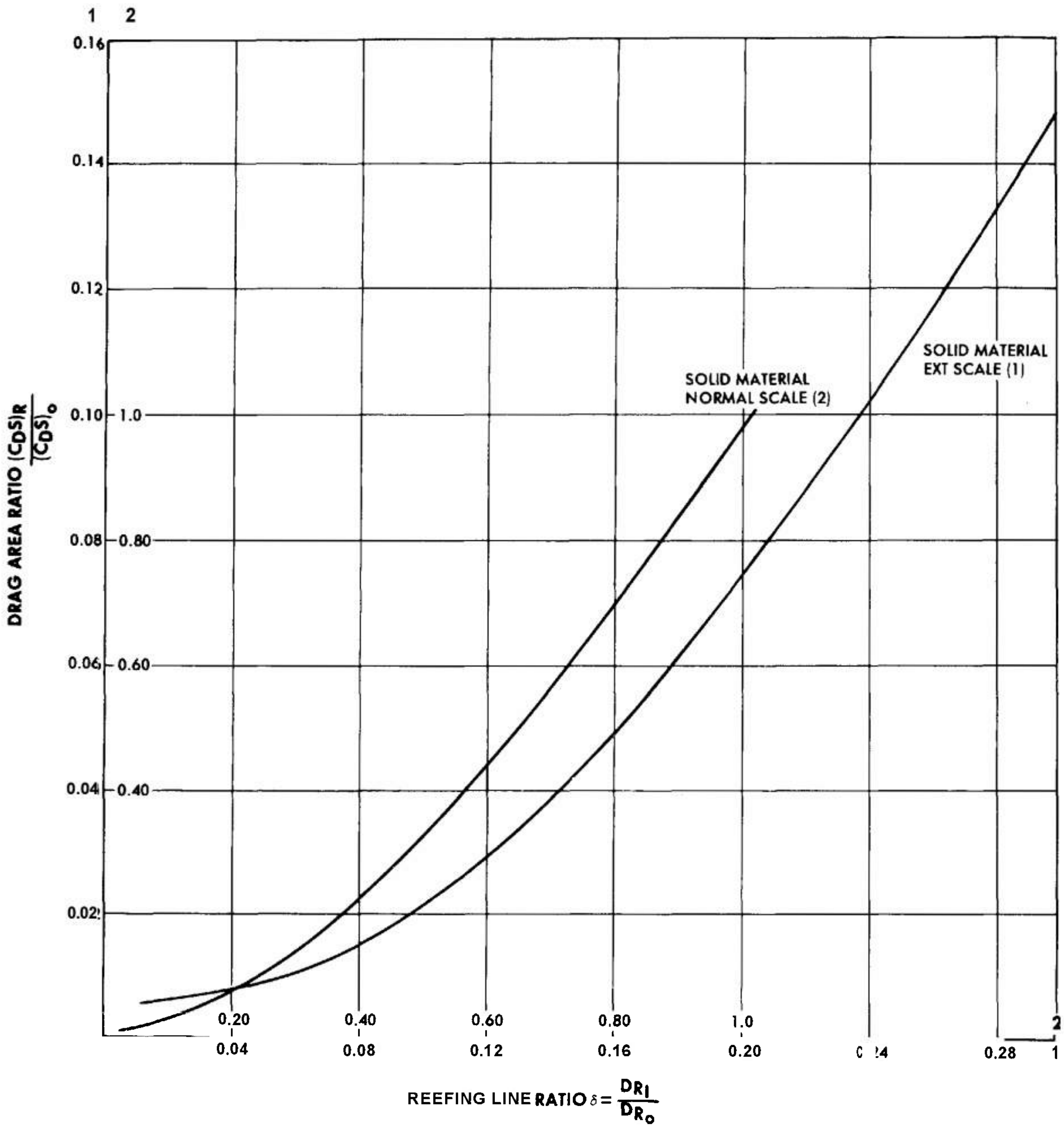


FIGURE 3–38. DRAG AREA RATIO VS REEFING LINE DIAMETER RATIO FOR EXTENDED SKIRT CANOPIES

series reefing line cutter (Fig. 3–40) has passed qualification tests during which it was successfully fired during 750-g shock and 500-g sustained acceleration tests. Time delay intervals are as follows: 2 seconds (M9), 4 seconds (M10), 6 seconds (M11), 8 seconds (M12), and 10 seconds (M13). The cutters, with the standard mounting plate (Drawing 64D22262) which is also used with the M21 cutter, will mount in standard reefing line cutter pockets. The M9 series cutter is capable of severing two 1000-pound tabular reefing lines and is used primarily by the Air Force.

3–15.1.7.2 Experimental Types. A number of disreefing devices actuated by electrical impulses and by clockwork and other mechanical means have been used in the past, or are under development, in an attempt to

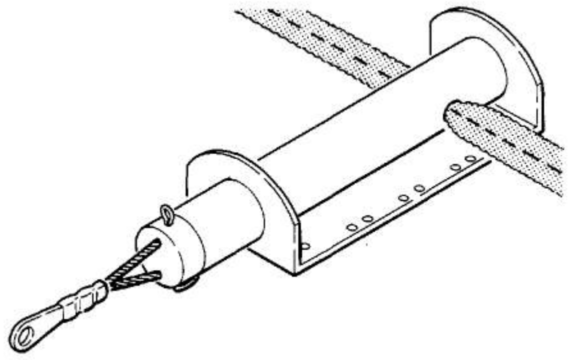


FIGURE 3-39. M21 REEFING LINE CUTTER

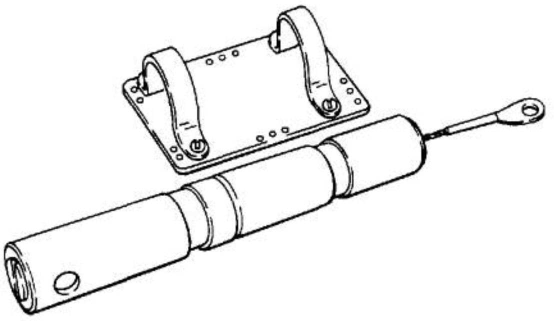


FIGURE 3-40. M9 REEFING LINE CUTTER

provide delay timing which is accurate under widely varying temperatures. The major difficulty encountered with these devices, especially those using mechanical timers, is the effect of the high g-shock on the timing-system operation during deployment.

3—15.1.7.3 Design Considerations. In designing a reefing line cutter, particular attention should be paid to the following details:

a. The piston-shaped knife must be longer than the diameter of the reefing line hole to prevent the high-pressure, propellant-genefated gases from escaping prematurely. Accurate fit of the cutter piston in the barrel is also important for the same reason.

b. Sufficient space must be provided beyond the reefing line hole for a full stroke of the cutter piston, so that the plug cut out of the reefing line can clear the ends of the line.

c. The powder charge must be well blocked-off from the firing mechanism.

3—15.2 DISCONNECTS. Most types of aerial delivery parachutes remain inflated under moderate wind velocities (10 knots or more) and 'tend to drag or overturn the load after ground impact. Disconnects are mechanical devices used primarily to separate the parachute canopy from the load after ground contact, reducing the chances of damage to the load. Most standard airdrop disconnects operate on the principle of load-stress reduction and incorporate a time-delay device to prevent premature mid-air release during canopy deployment and descent. The disconnects are installed between the suspension slings of the load and the cargo parachute risers or riser extensions, and are available for load capacities ranging frdm 200 to 35,000 pounds.

3—15.2.1 Standard Types

3—15.2.1.1 Multiple Release Assembly. The multiple release assembly (Fig. 3-41) may be used with loads requiring three to six G-11A cargo parachutes. A 10-second delay reefing line cutter is required. One

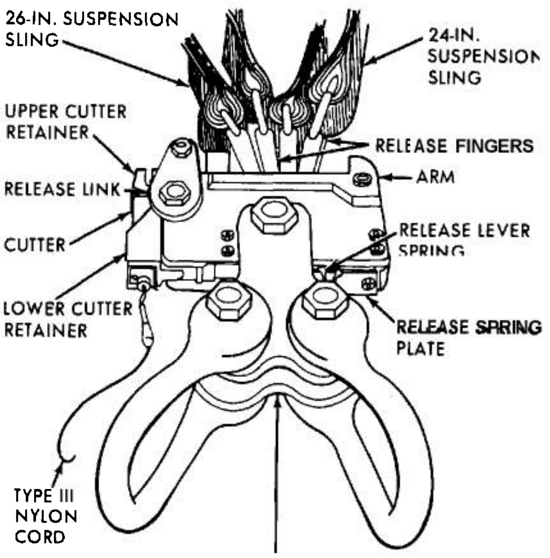


FIGURE 3-41. MULTIPLE RELEASE ASSEMBLY WITH ADAPTER, SLINGS, AND CUTTER INSTALLED

suspension sling is required for each parachute for attachment to the platform load. The release assembly adapter is required to attach the multiple release assembly when two clevises are required on the load suspension system.

3—15.2.1.2 Cargo Parachute Release (5000-Pound Capacity). The 5000-pound capacity cargo parachute release (Fig. 3—42) is used with one G-11 or G-11A cargo parachute, one to three G-12D cargo parachutes, or one G-12C cargo parachute. The release uses one 20-second delay cartridge and may require clevises and the 8-spool or 12-spool load coupler for attachment to the load.

3—15.2.2 Experimental Types. Ground-disconnect parachute releases of 20,000- and 35,000-pound gross rigged weight capacities have been developed based on the load sling tension difference or tilt-type mechanism. Engineering design tests of these devices are in progress[20].

3—15.2.3 Associated Equipment. Load couplers and large clevis assemblies are used to install the 5000-pound capacity cargo release when required by a complex load suspension system. The 8-spool load coupler is used with airdrop loads requiring two to four G-11A cargo parachutes. The 12-spool load coupler is used for airdrop loads requiring five or six G11A cargo parachutes. When the number of suspension slings exceeds the number of spacers available on the coupler, large clevises are used to join the suspension slings to the coupler, as shown in Fig. 3-43. Where only one parachute release is required — such as when two or three G-12D cargo parachutes are used — two 3-foot slings and two large clevis assemblies are used, as shown in Fig. 3—44.

3—16 EXTRACTION PARACHUTE AND FORCE TRANSFER GROUP

3—16.1 EXTRACTION PARACHUTES. The most common method of load ejection from aft-loading cargo aircraft is by means of an extraction parachute large enough to provide the force necessary for extraction of the palletized load from the aircraft in flight. The ring-slot canopy (Fig. 3—45) is generally used for extraction purposes. Extraction parachutes are reefed or unreefed depending upon the specific airdrop load, and may be used singly or in clusters. Extraction parachutes are generally attached to 60-foot extraction lines of appropriate strength, except that 120-foot lines are used when airdropping from C-141 aircraft.

3—16.1.1 Types and Sizes

3—16.1.1.1 15-Foot Cargo Extraction Parachute. The 15-foot cargo extraction parachute consists of a 1&foot-diameter, ring-slot nylon canopy with suspension lines; a 2-loop nylon extraction line equipped with a shear knife and V-rings; and a nylon or cotton duck cloth and webbing deployment bag. The

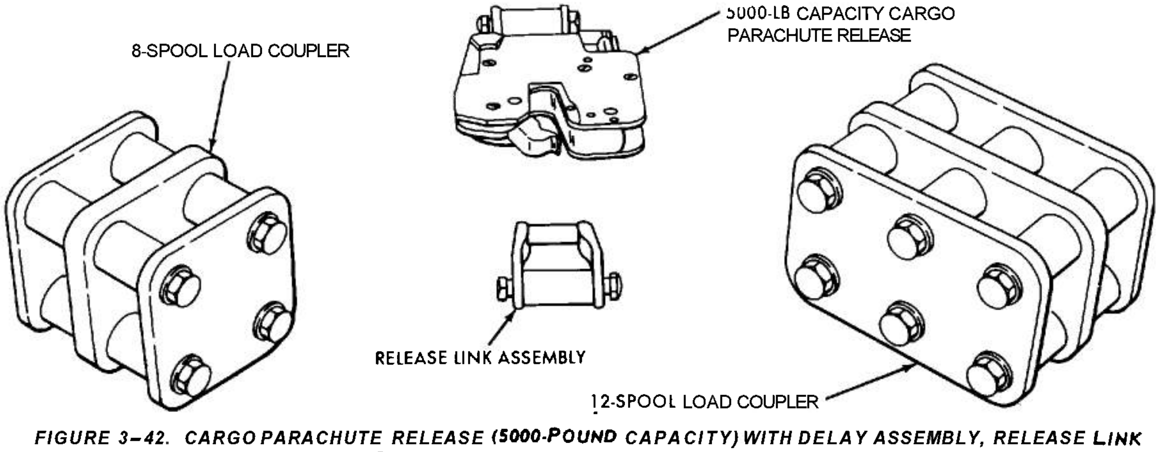


FIGURE 3-42. CARGO PARACHUTE RELEASE (5000-POUND CAPACITY) WITH DELAY ASSEMBLY, RELEASE LINK ASSEMBLY, AND 8-SPOOL AND 12-SPOOL LOAD COUPLERS

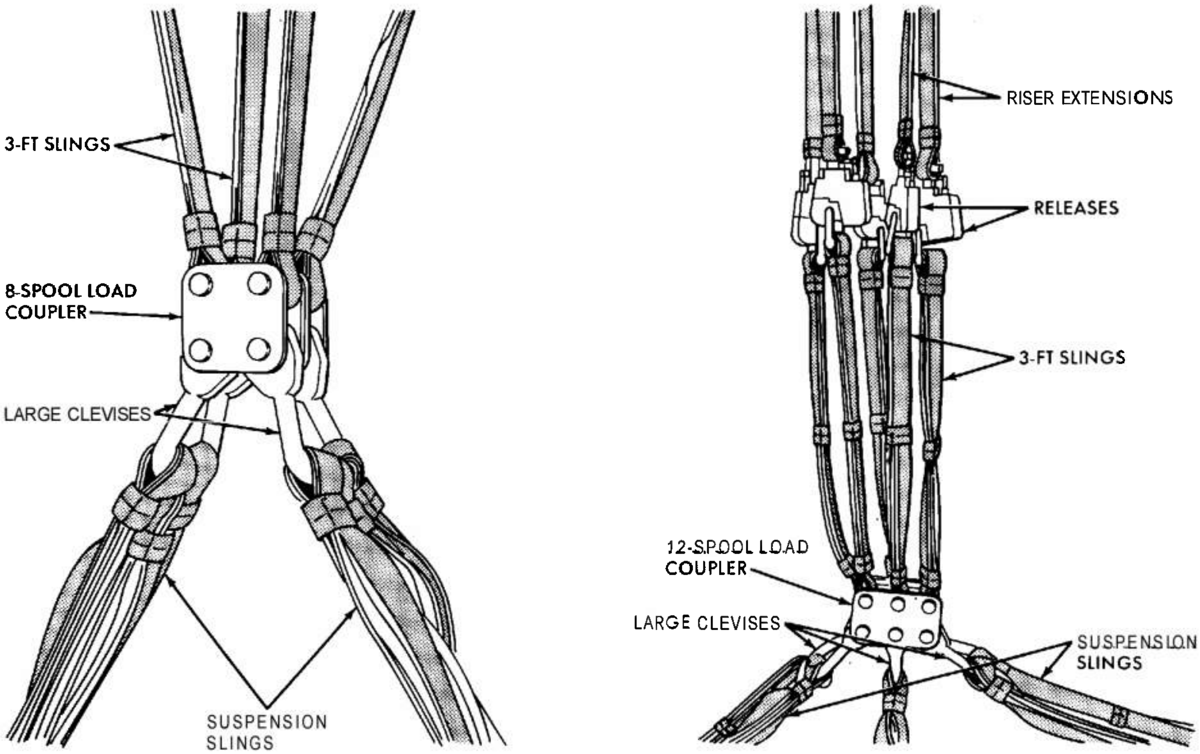


FIGURE 3-43. TYPICAL RELEASE INSTALLATION WITH LOAD COUPLER AND LARGE CLEVISES

skirt of the extraction parachute canopy may be reefed with either a 148-inch or 260-inch nylon webbing reefing line.

3—16.1.1.2 22-foot *Cargo* Extraction Parachute. The 22-foot cargo extraction parachute consists of a 22-foot-diameter, flat circular, ring-slot nylon canopy with suspension lines; a 3-loop nylon extraction line equipped with three shear knives and a V-ring; a 5-foot adapter web; and a nylon or cotton duck cloth and webbing deployment bag.

3—16.1.1.3 *28-Foot Cargo* Extraction Parachute. The 28-foot' cargo extraction parachute is similar to the 22-foot parachute except for the extraction line, which is a 4-loop nylon line equipped with three shear knives and a V-ring.

3—16.1.2 Technical Characteristics. All of the extraction parachutes used are standard; the size selected depends on the gross weight of the load, as tabulated in Table 3—4, for the skate wheel and dual-rail systems. Other characteristics are listed in Table 3—5.

3—16.1.3 Design Criteria. Extraction canopies must have a design that is simple and dependable. An important requirement is that they perform reliably in the wake of the aircraft. Another requirement is good stability. The size of the extraction canopy is determined by the force necessary to remove the load from the aircraft compartment. To insure proper inflation, risers must be of sufficient length to minimize the aircraft-wake effect. The system must be designed to insure that the canopy is so placed during and after inflation that it does not interfere with the aircraft structure. Extraction lines for each range of weights are designed on the basis of an ultimate breaking strength of 1.5 times the maximum cargo weight, multiplied by a safety factor of 2.0 and a stitching efficiency loss factor of 80 percent.

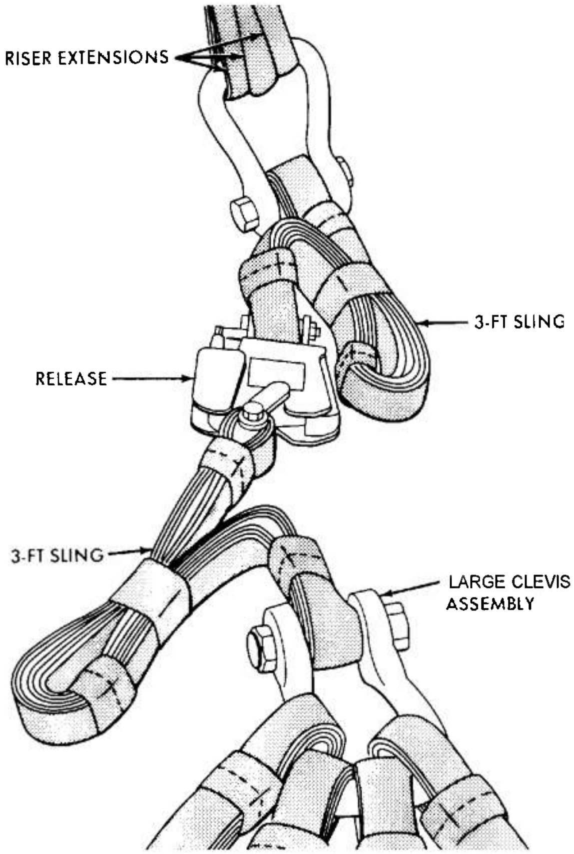


FIGURE 3-44. TYPICAL RELEASE INSTALLATION WITH THREE G-12D CARGO PARACHUTES

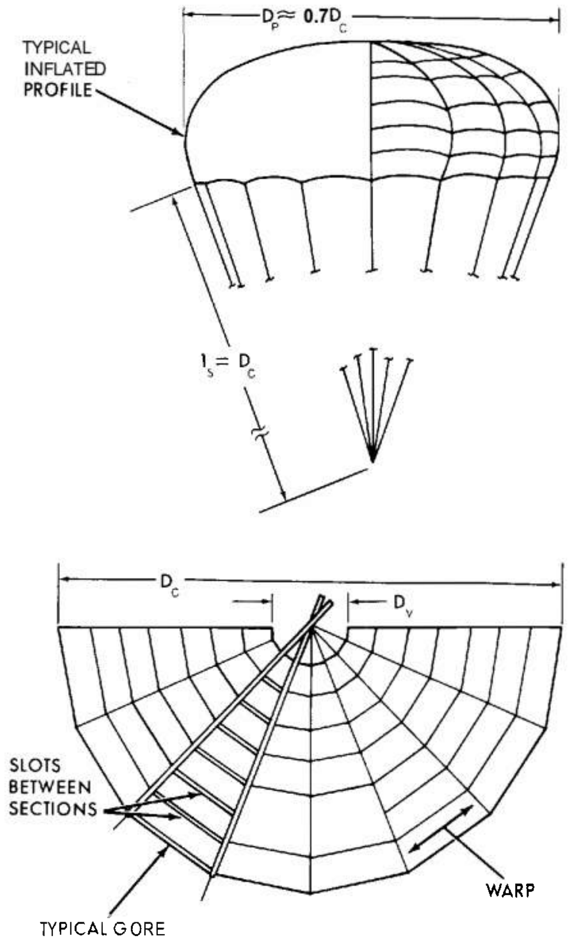


FIGURE 3-45. RING-SLOT CANOPY

EXTRACTION PARACHUTE SIZE AND TYPE	EXTRACTED LOAD RANGE (lb)		EXTRACTION LINE
	SKATE WHEEL SYSTEM	DUAL-RAIL SYSTEM	
15-foot reefed ring-slot (148-inch reefing line)	1,750 to 3,500	---	2-loop Type X nylon
15-foot reefed ring-slot (260-inch reefing line)	3,500 to 7,000	2,520 to 5,070	2-loop Type X nylon
15-foot ring-slot (unreefed)	5,600 to 11,200	3,730 to 8,000	2-loop Type X nylon
22-foot ring-slot (unreefed)	11,200 to 21,500	8,000 to 17,000	3-loop Type X nylon
28-foot ring-slot (unreefed)	---	13,000 to 25,000	4-loop Type X nylon
Two 28-foot ring-slot (unreefed)	---	25,000 to 35,000	5-loop Type XXVI nylon

TABLE 3–5. EXTRACTION PARACHUTE CHARACTERISTICS

ABBREVIATED NOMENCLATURE	WEIGHT+ (lb)	METHOD OF DEPLOYMENT	CANOPY			SUSPENSION LINES			DEPLOYMENT BAG AND/OR PACK
			TYPE	NOMINAL DIAMETER (ft)	TYPE OF MATERIAL	NUMBER	LENGTH (ft and in.)	TYPE OF MATERIAL	
15-Ft Extraction	8.0	Pendulum Line or Pilot Chute w/weight	Ring-slot	15	4.25 oz Rayon Cloth	16	15 ft 0 in.	Type IV Braided Nylon or Type II Braided Rayon Cord	Deployment Bag
15-Ft Extraction	8.0	Pendulum Line or Pilot Chute w/weight	Ring-slot	15	2.25 oz Nylon Cloth	16	15 ft 0 in.	Type IV Braided Nylon Cord	Deployment Bag
22-Ft Extraction	27.5	Pendulum Line	Ring-slot	22	3.50 oz Nylon Cloth	28	22 ft 0 in.	Type V Braided Nylon Cord	Deployment Bag
28-Ft Extraction	36.5	Pendulum Line	Ring-slot	28	2.25 oz Nylon Cloth	30	28 ft 0 in.	Type VI Braided Nylon Cord	Deployment Bag

+Approximate packed weight of entire parachute assembly

3—16.2 FORCE TRANSFER. In airdrops where the extraction parachute force is also used to deploy the recovery parachutes, provisions must be made for transferring the extraction force from the extraction process to the recovery system. This force transfer is usually effected through the use of load transfer devices which redirect the extraction parachute force from extracting the load to the deployment of the recovery parachutes. The devices and methods used to accomplish force transfer on various loads are outlined in the paragraphs which follow.

3—16.2.1 Platform Extraction

***3—16.2.1.1 J-1* Platforms.** On J-1 platforms, an extraction bar assembly (Fig. 3-46) is mounted on the underside of the platform. The hinged lever, called the extraction bar, is normally held in the forward position by springs. The shoe end of the assembly points toward the front of the aircraft as shown in view A of Fig. 3-47. The force of the extraction parachute is exerted through the extraction line and dual link on the extraction bar. The cargo floor prevents the extraction bar from moving along its pivotal arc. The force thus acts to move the load over the wheeled conveyors in the direction of the applied force. When the extraction bar passes the aft edge of the aircraft, as shown in view B, Fig. 3-47, it is no longer restricted along its pivotal arc. The extraction force causes the extraction bar to pivot, freeing the dual link from its recess. The dual link separates from the platform and serves to join the extraction parachute to the deployment bags of the recovery parachutes.

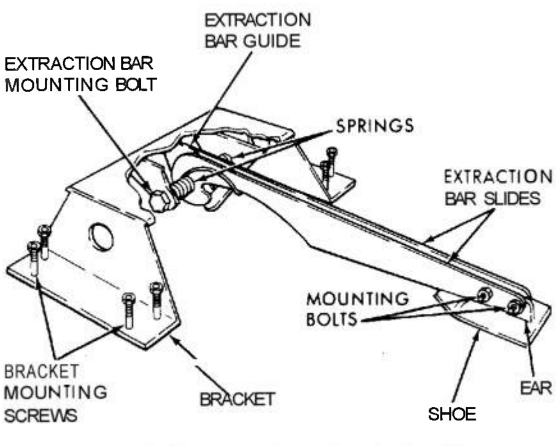


FIGURE 3-46. EXTRACTION BAR ASSEMBLY

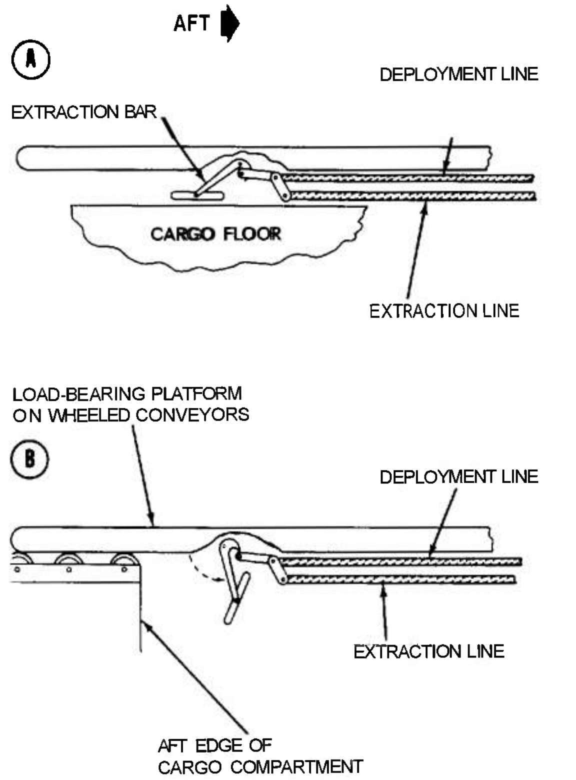


FIGURE 3-47. TYPICAL OPERATION OF EXTRACTION BAR FOR RELEASE AND FORCE TRANSFER

***3—16.2.1.2 Standard B* Platforms.** The 11-foot and 15-foot standard B platforms have extraction bars similar to the extraction bar described on the J-1 platform. The 22-foot platform employs a built-in release and load transfer device utilizing a plug assembly located in the aft end of the platform (Fig. 3-48). The extraction line is attached to the plug which is made in two interlocking parts. The plug is connected to the extraction lever through a linkage under the platform. The extraction lever on this platform serves the same purpose as the extraction bar on the other platforms. When the extraction lever is in the forward position, as shown in view A, Fig. 3-49, the plug is retracted far enough into the housing so that its two parts cannot separate.

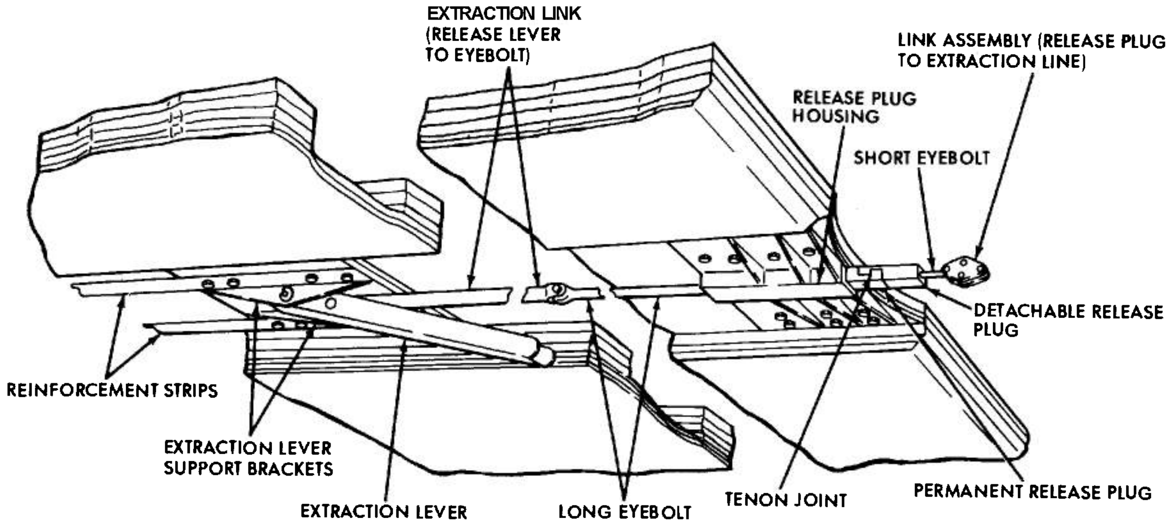


FIGURE 3-48. EXTRACTION RELEASE SYSTEM, 22-FOOT PLATFORM ASSEMBLY

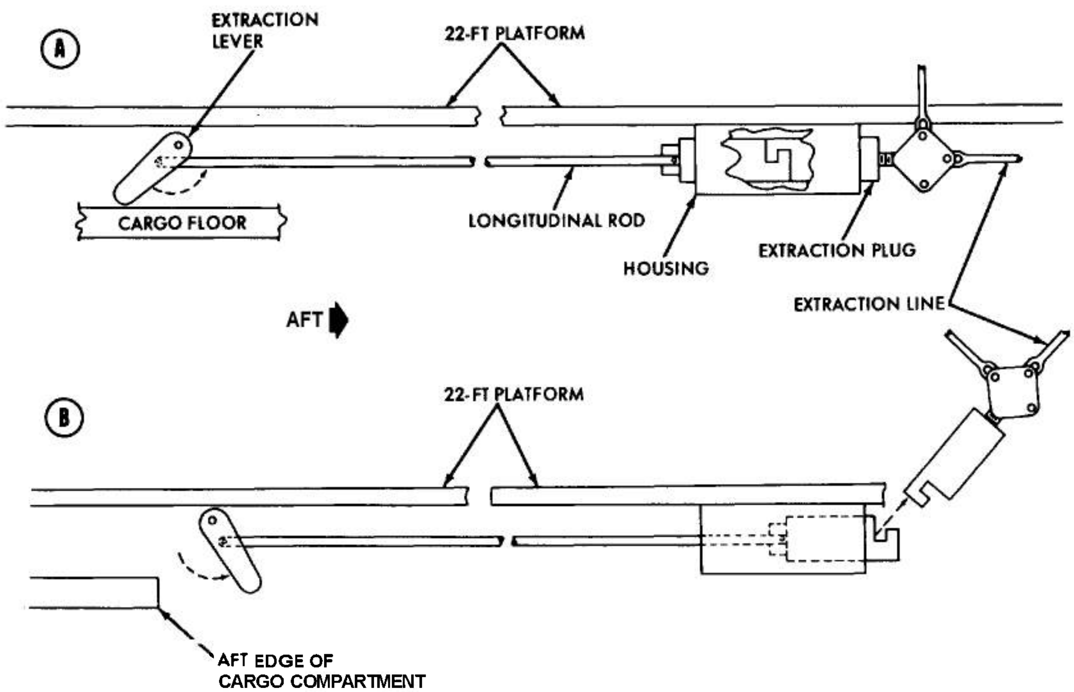


FIGURE 3–49. TYPICAL OPERATION OF EXTRACTION LEVER FOR RELEASE AND FORCE TRANSFER

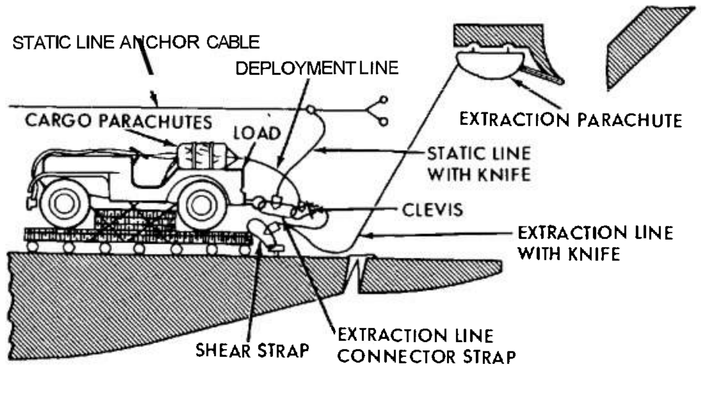
When the platform clears the aft edge of the ramp, the extraction lever turns until it points aft, as shown in view B, Fig. 3-49. This actuates the linkage and causes the plug to protrude from the housing, thus separating the two parts. When the plug separates, the extraction parachute is linked to the deployment bags of the recovery parachutes accomplishing the force transfer.

3—16.2.2 Item Extraction

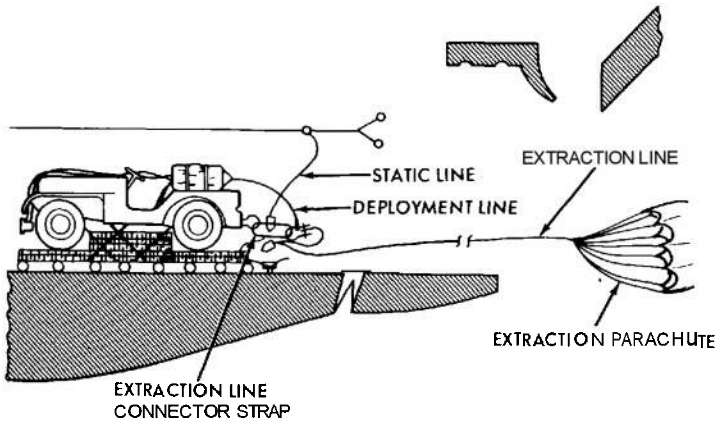
3—16.2.2.1 Static Line-Shear Knife Transfer. On the combat-expendable and modular platforms systems, the extraction force is usually applied directly to the load instead of the platform. The force transfer is accomplished by the action of a static line and shear knife deployed as the load leaves the aircraft. The sequence of extraction and force transfer for this type of system is schematically shown in Fig. 3—50.

3—16.2.2.2 High Capacity Force Transfer Coupling. The high capacity force transfer coupling system shown in Fig. 3—51 provides the means of releasing the extraction parachute from the load and transferring the extraction force to deployment of the recovery parachutes. This coupling consists of a latch assembly (Fig. 3—52), a parachute connector link assembly (Fig. 3—53), an actuator assembly (Ag. 3—54), and a flexible control cable. The coupling is designed for use with modular side-rail platforms and the aerial unloading kit of the C-130 and C-141 aircraft; however, it can be used on the C-119 aircraft without dual-rail unloading kit by modification of the actuator assembly. Operation of the coupling requires that the flexible control cable be attached to the actuator assembly. The actuator assembly is then attached at a predetermined point to the side rail of the platform. The control cable is extended toward the rear of the platform. The latch assembly is fastened to the load by attaching a clevis eye to it by means of a 1-inch bolt. The eye is next attached to the pintle or lunette eye of the load. If a vehicle has a special latch-mounting bracket, the latch assembly is attached to this bracket by means of a 1-inch bolt that passes through the mounting hole. The flexible control cable is. attached to the latch assembly catch, and the cam in the extraction parachute link is engaged by the retainer hook and sideplates of the latch assembly. The trigger arm is drawn forward temporarily and locked with a pin, until the load has been positioned in the aircraft. Thereafter the locking pin is removed, the trigger arm is retracted, and the guide rod, under spring tension, is forced against the aircraft guide rail. The end loop of the extraction parachute line is attached to the outboard pin of the extraction parachute link, and the end loop of the recovery parachute deployment line is attached to the top pin of the link. When the extraction parachute is deployed, the force developed along the extraction line pulls the load from the aircraft. As the guide rod and trigger arm come clear of the aircraft's guide rails, the spring-loaded trigger arm snaps forward, pulling the flexible control cable, actuating the latch assembly, and releasing the extraction parachute link, which pulls the deployment bag from the recovery parachutes. Thus, the extraction force, which takes the load from the aircraft, is transferred to deployment of the recovery parachutes. The extraction parachute and line, the parachute deployment bags, and the extraction link assembly descend independently from the load. Modification of the device for use with platforms used in C-119 aircraft without the dual-rail unloading kit consists of a rearrangement of the trigger assembly, so that the trigger arm rides the floor of the aircraft. The retracted arm is released when the platform passes over the rear edge of the aircraft ramp. Thereafter, the procedure described above takes place.

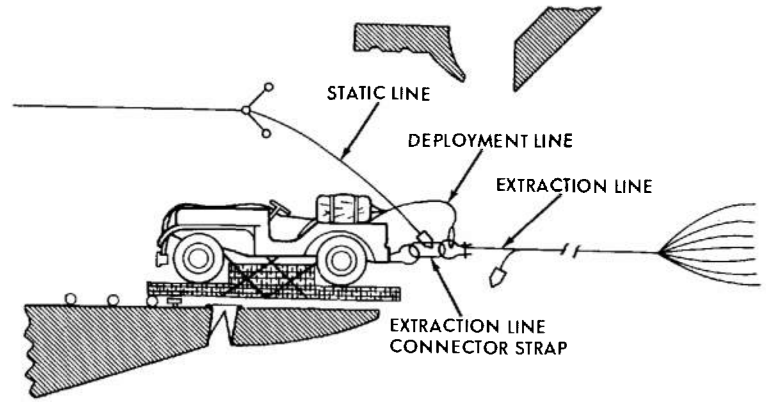
3—16.2.3 Associated Equipment. Two breakaway static line assemblies are attached to the connector strap loop and the extraction clevis of each modular or combat-expendable platform load delivered from the C-119, C-123, C-130, and the C-141 aircraft. One static line assembly is used for airdrop from the CV-2B aircraft. Each static line assembly consists of a 15-foot static line, an 18-foot release line, and a 6-inch retainer strap. The static line is constructed of 1-3/4-inch wide, type VIII cotton webbing, with an additional 11-1/2-foot ply sewed to the line to form a sleeve through which a release line passes. The static line has a release knife at one end and an attaching loop at the other end. A safety loop is sewed to the static line



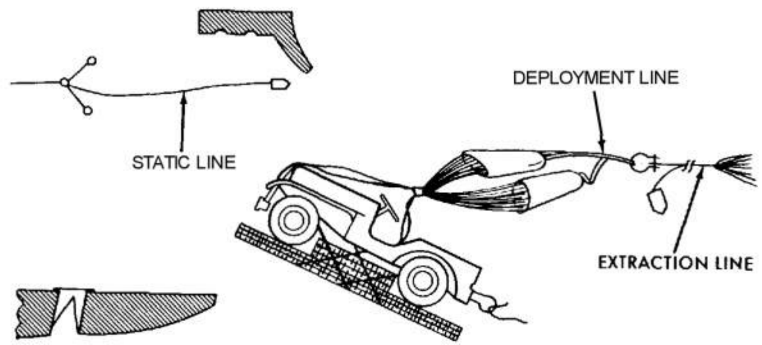
1 LOAD IS POSITIONED IN CARGO AIRCRAFT WITH PENDULUM EXTRACTION MECHANISM READY TO RELEASE EXTRACTION PARACHUTE.



2 EXTRACTION PARACHUTE IS RELEASED. PARACHUTE DEPLOYS, EXTENDING EXTRACTION LINE.



3 EXTRACTION PARACHUTE PULLS RELEASE KNIFE THROUGH SHEAR STRAP, PULLING LOAD OUT OF AIRCRAFT.



4 STATIC LINE RELEASE KNIFE CUTS EXTRACTION LINE CONNECTOR STRAP AS LOAD IS PULLED OUT OF AIRCRAFT. EXTRACTION PARACHUTE BEGINS TO DEPLOY CARGO PARACHUTES.

FIGURE 3-50. TYPICAL EXTRACTION AND FORCE TRANSFER SEQUENCE (STATIC LINE–SHEAR KNIFE TRANSFER)

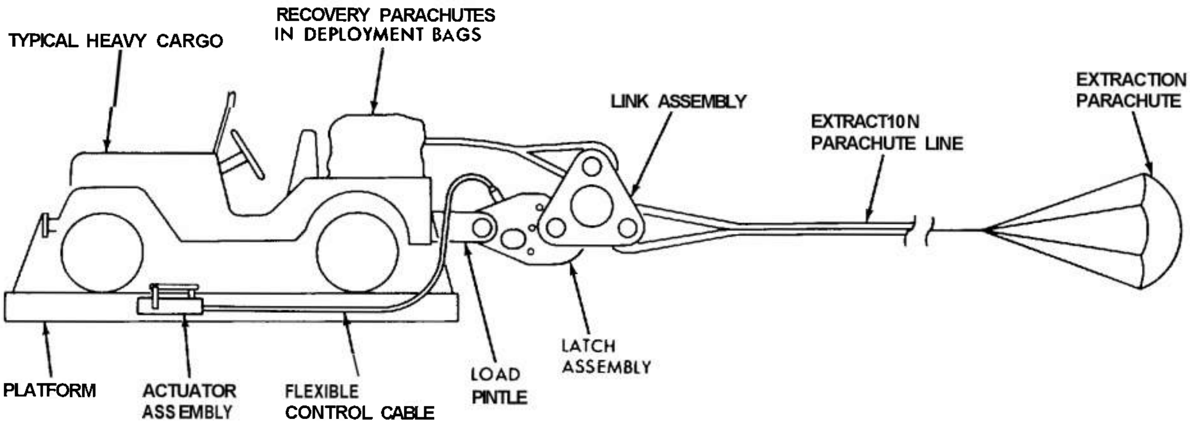


FIGURE 3–51. EXTRACTION FORCE TRANSFER COUPLING SYSTEM (HIGH CAPACITY)

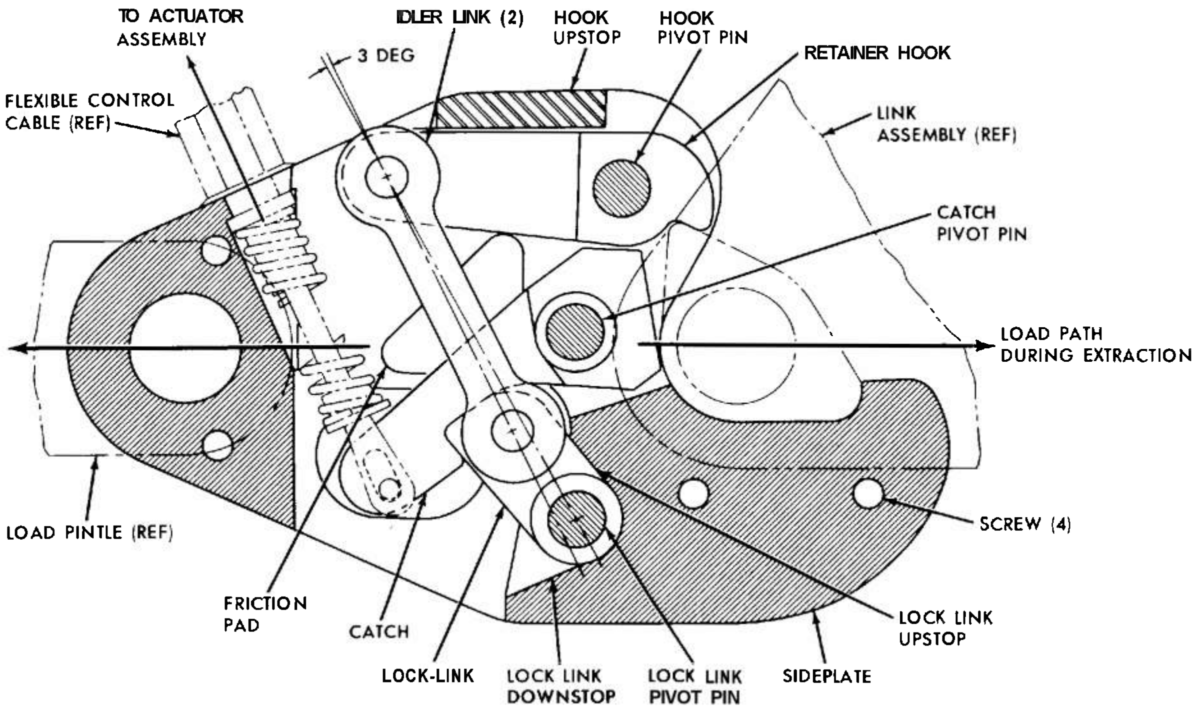


FIGURE 3–52. LATCH ASSEMBLY

approximately 12 inches from the release knife. The release line is constructed of type VIII nylon webbing rolled to a 3/4-inch width, with an attaching loop at each end. The large loop at the lower end of the release line is reinforced with a sleeve of type IV cotton duck. The retainer strap is constructed of 1-3/4-inch wide, type VIII nylon webbing, with a connector link at one end and a clevis at the opposite end.

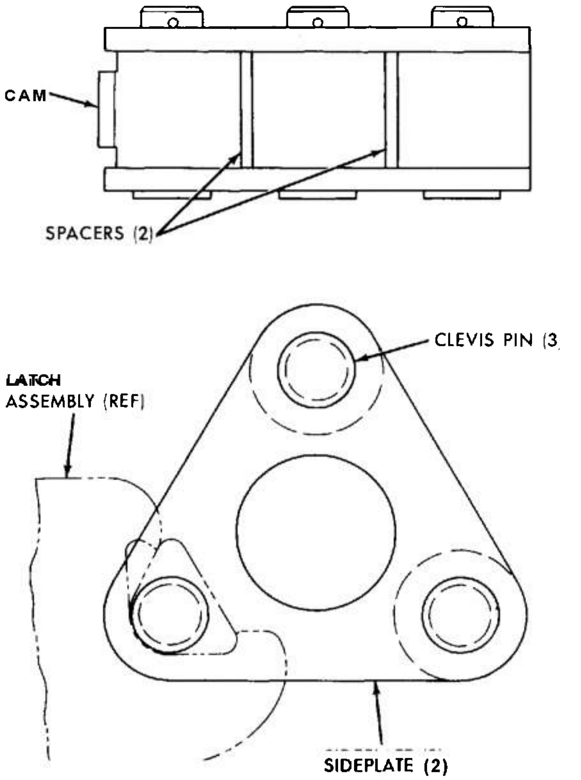


FIGURE 3-53. PARACHUTE CONNECTOR LINK ASSEMBLY

3-17 RESTRAINT GROUP

When preparing an airdrop platform load, the equipment and any accompanying supplies must be secured in such a manner as to insure that no damage will occur to the rigged load or the aircraft during flight, extraction sequence, parachute deployment, and ground impact. The equipment and supplies are secured to the platforms by use of lashing and nets.

3-17.1 **LASHING.** The number of lashings and attachment locations for securing standard airdrop loads are contained in TM 10-500 series. A lashing consists of a 15-foot tiedown strap, a strap fastener, a D-ring, and a load binder. The number and combination of these items determine the type of lashing as follows:

a. Type I. Type I lashing requires one 15-foot tiedown strap, a D-ring, one strap fastener, and one load binder. Figure 3-55 illustrates typical type I lashing.

b. Type II. Type II lashing requires one 15-foot tiedown strap, a D-ring, one strap fastener, and two load binders. Figure *3-55* illustrates typical type II lashing.

c. Type III. Type III lashing requires two 15-foot tiedown straps, two D-rings, two strap fasteners, and one load binder. Figure *3-55* illustrates typical type III lashing.

d. Type IV. Type IV lashing requires two 15-foot tiedown straps, two D-rings, two strap fasteners, and two load binders. Figure *3-55* illustrates typical type IV lashing.

3-17.2 **NETS.** An airdrop cargo restraint system made up of one top net (Fig. **3-56**) and four side nets (Fig. 3-57) is used to restrain bulk airdrop cargo weighing up to 12,000 pounds. The nets are 10 feet long, 6 feet wide, and are constructed of 1-inch nylon webbing. The top net is equipped with reefing rings to which the side nets are attached. The four side nets are equipped with attachment hooks, several rows of reefing rings, and a colored strap marking the transverse centerline of the net. The hooks permit attachment of the side nets to the top net, and the reefing rings permit attachment of tiedown straps to the side nets. Vertical restraint is accomplished by using tiedown straps in the reefing rings in the side nets. The nets are secured to the airdrop platform by use of tiedown assemblies (Fig. *3-58*). The nets have ultimate load factors of **4** g's forward and rearward and 2 g's upward and sidewise.

3-18 PLATFORM GROUP

Airdrop platforms are used in airdrop for the following purposes:

a. To serve as a base upon which stacks of energy dissipater material may be arranged to provide maximum protection for a variety of airdrop items during impact.

b. To provide a suitable rolling surface for safe extraction of airdrop items from aircraft in flight.

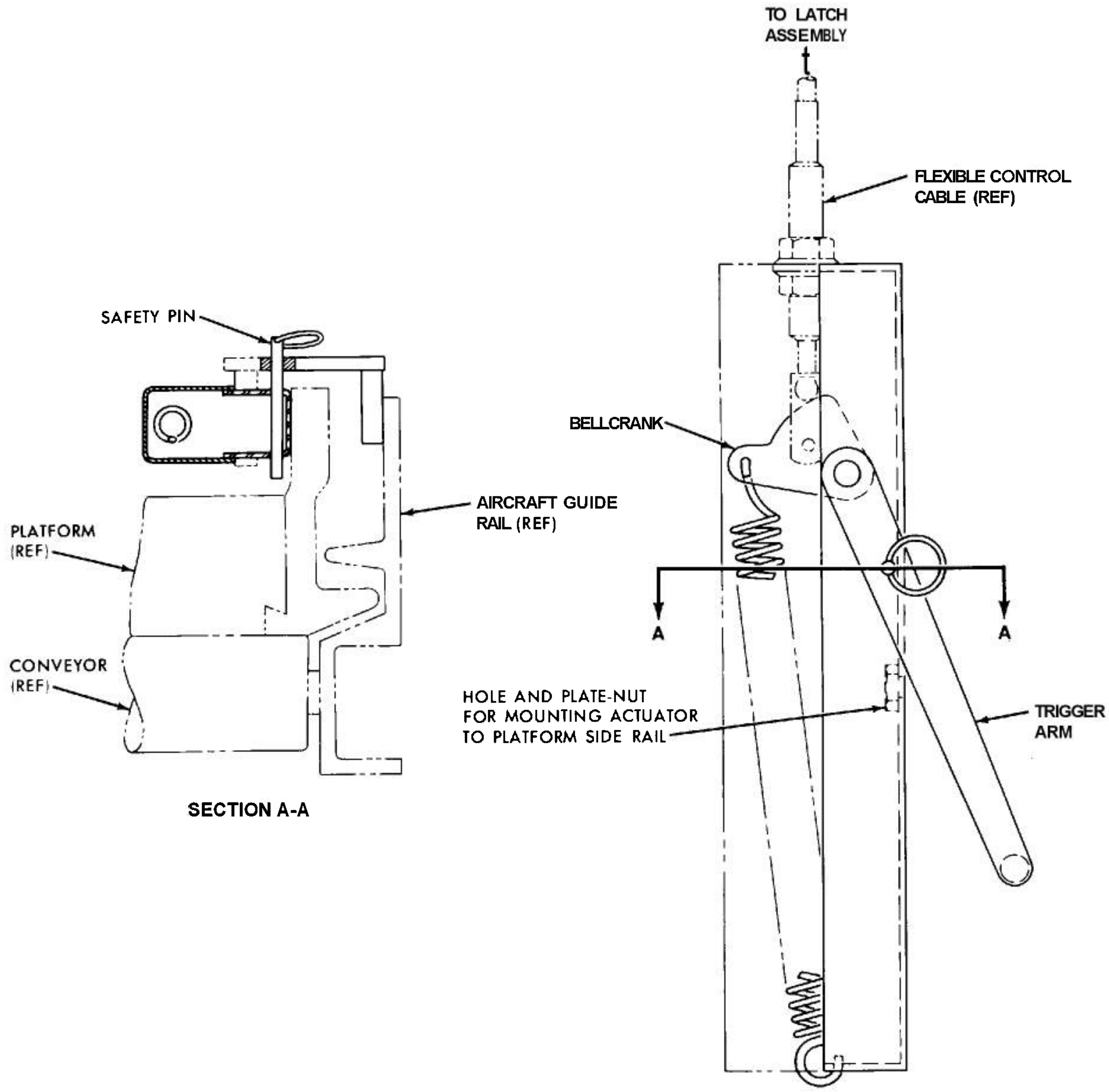


FIGURE 3-54. ACTUATOR ASSEMBLY

c. When used in dual-rail systems, to provide' suitable structure for distributing restraint forces into the aircraft structure.

d. When used as load-bearing platforms for airdrop of items which are nonrigid or structurally weak, to provide a structure **for** resisting parachute opening forces.

3—18.1 TYPES AND SIZES

3—18.1.1 J-1 **Platform.** The **J-1** platform (Fig. **3—59)** is **a** load-bearing platform used with the skate wheel and buffer board system. The platform is a flat skid 80 inches wide and **144** inches long, constructed of aluminum framing and plywood panels with

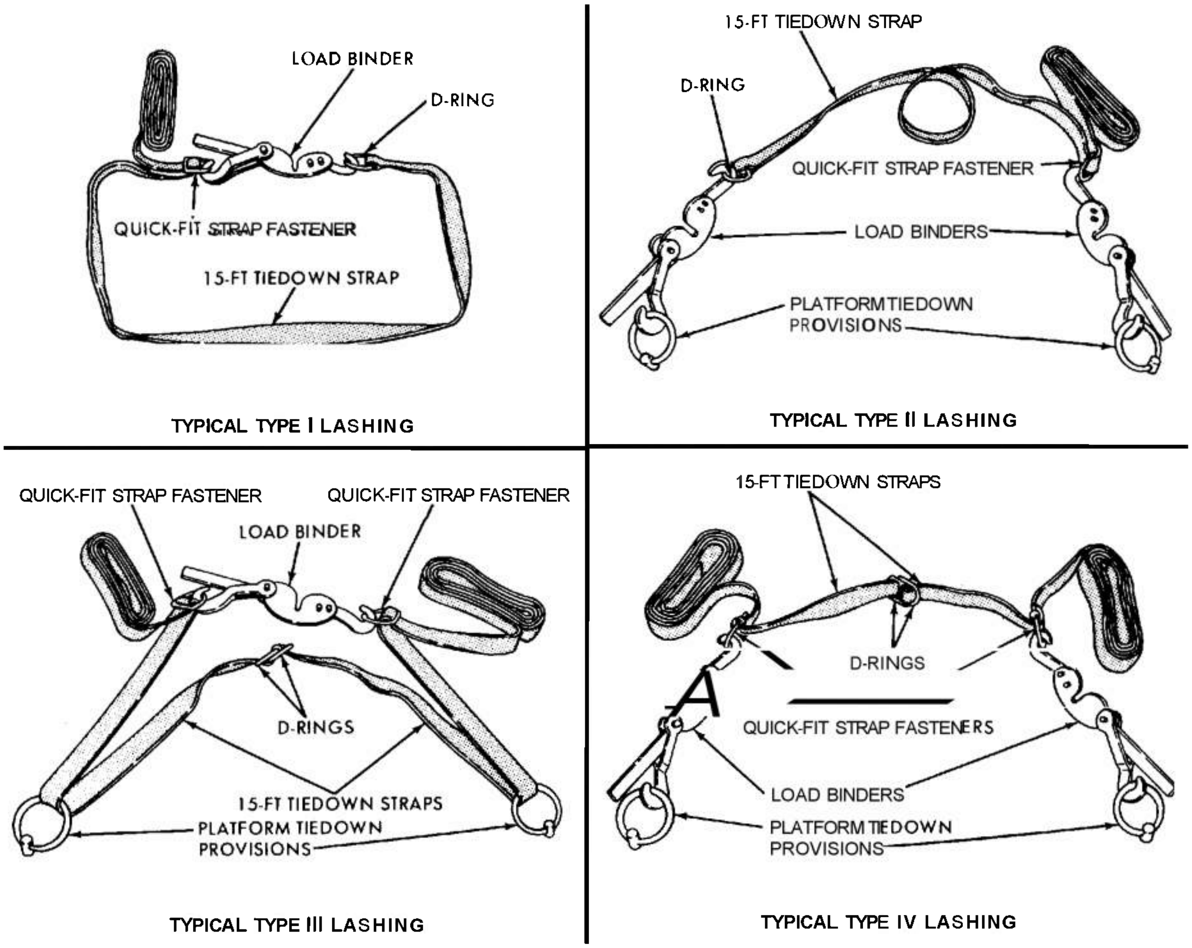


FIGURE 3–55. TYPICAL TYPES OF LASHING

sheet aluminum bolted to the underside. The top of the platform is covered with a decking of corrugated sheet aluminum serving as the cargo floor. An extraction bar is installed on the platform wall to provide a point of attachment for the extraction line extension and parachute deployment line. Sixteen tiedown rings are installed around the edges of the cargo floor to provide anchoring stations for lashings and tiedown devices. The J-1 platforms are designed for delivery of 6000-pound loads and should not be dropped at a gross weight of less than 2800 pounds. Loads of up to 10,000 pounds rigged weight may be authorized as emergency combat overloads. The platforms are stressed to withstand the opening shock of cargo parachutes. Four suspension points are provided for attaching suspension systems directly to the platform.

3—18.1.2 Standard B Platforms. Standard B platforms (Fig. 3—60) are constructed primarily of wood and covered with sheet metal on the underside. These platforms are not stressed, and therefore suspension systems are attached directly to the rigged item. The most commonly used standard B platforms are: 11-foot, 15-foot, and 22-foot platforms. These platforms are usable only with the skate wheel and buffer board systems. They are being replaced by combat-expendable platforms (par. 3—18.1.4) and will eventually be obsoleted.

3—18.1.2.1 11-Foot and 15-Foot Platforms. The 11- and 15-foot platforms (Fig. 3—60) are flat

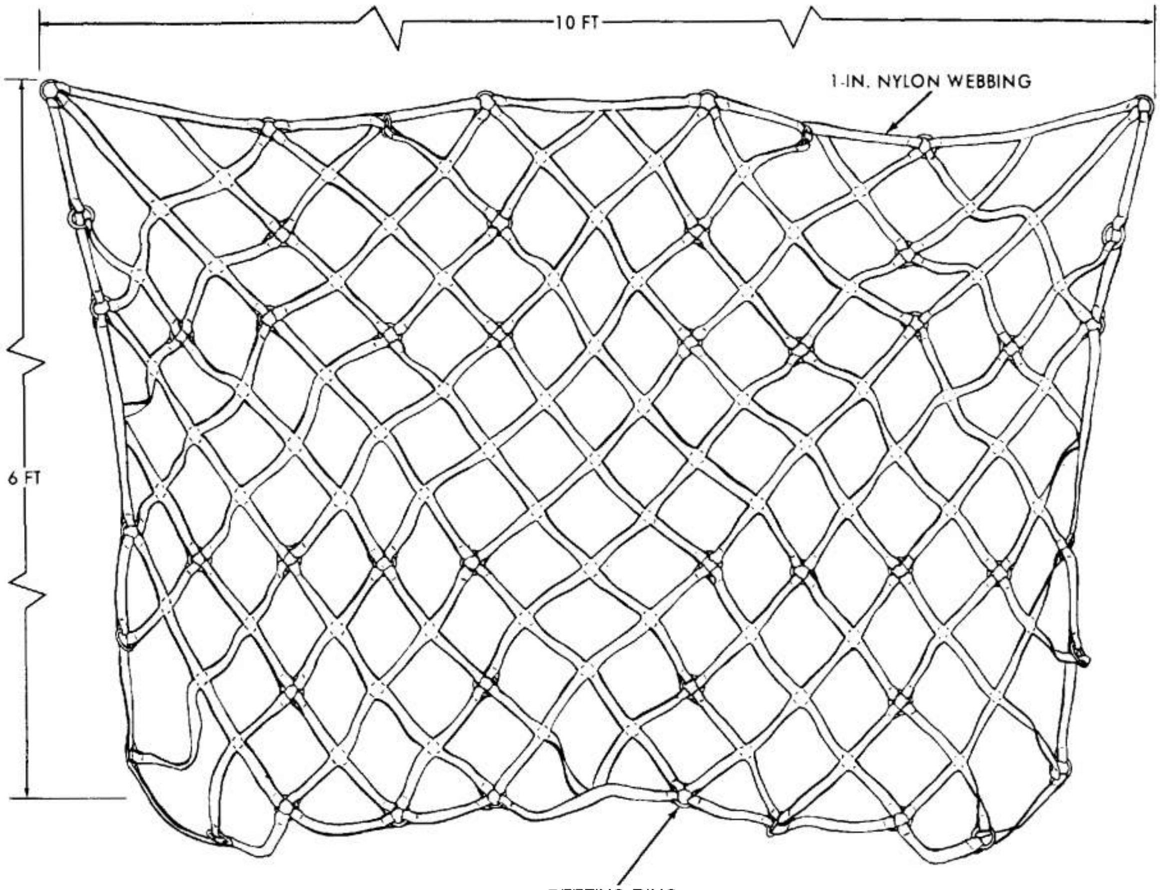


FIGURE 3-56. TYPICAL TOP NET

rectangular skids 80 inches wide. The platforms are constructed of wood framing with plywood paneling on the underside, and with plywood end panels and reinforced plates on the top side. The undersurface is covered with sheet metal to minimize friction and insure a safe exit from the aircraft in flight. An extraction bar with a bracket is provided for attachment of the extraction line extension and deployment line. Tiedown rings are located around the top edges of the platform for securing lashings and tiedown devices. The 11-foot platform is provided with 10 tiedown rings and the 15-foot platform with 16 tiedown rings. The 11-foot platform has a minimum rigged-weight limitation of 2570 pounds and the 15-foot platform 3740 pounds.

3—18.1.2.2 **22-Foot** ***Platform.*** The 22-foot platform (Fig. **3—60)** is a flat rectangular skid 100 inches wide, constructed of wood framing with plywood end panels and reinforcing plates. The Undersurface is covered with sheet metal. An extraction line may be attached to **a** plug assembly located in the aft end of the platform. Twenty tiedown rings are installed around the **top** edges **of** the platform to provide anchoring stations for lashings and tiedown devices. The 22-foot platform has a minimum rigged-weight limitation of 6420 pounds.

3—18.1.3 Modular Platforms

3—18.1.3.1 **Aluminum** ***Modular Platforms.*** Aluminum modular platforms (Fig. 3-61) are specially designed for use with the dual-rail systems. They are 108 inches wide and can be assembled in the field in 8-, 12-, **16-**, 20-, and 24-foot lengths. The platforms con-

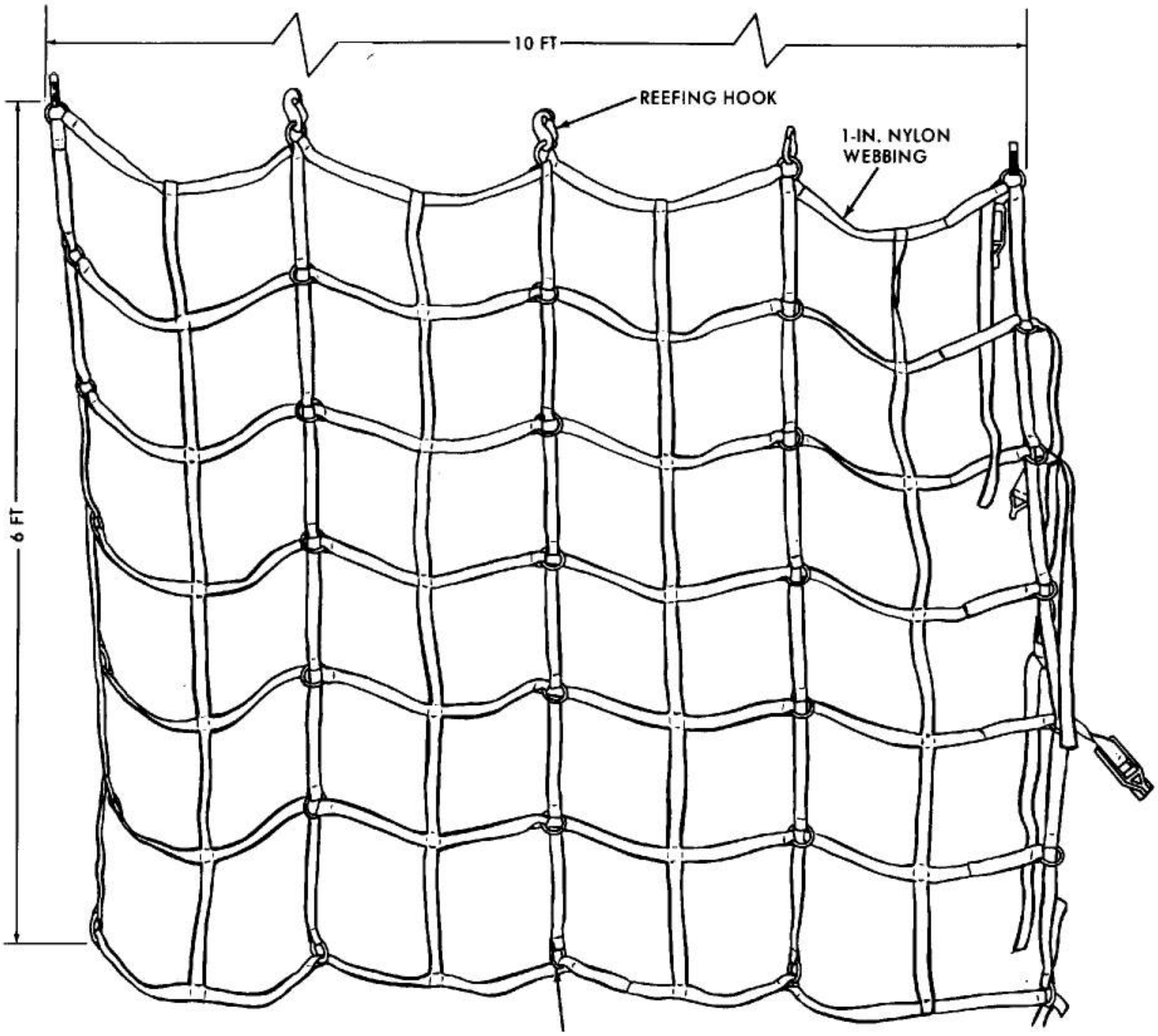


FIGURE 3–57. TYPICAL SIDE NET

sist of sandwich-constructed panels of aluminum and balsa or foamed plastic. Aluminum alloy side rails are attached to the side of the panel to complete the assembly. The type I solid rails are compatible to dual-rail systems using fixed-pin restraint mechanisms, and the type II notched rails are compatible to dual-rail systems using indent/detent restraint mechanisms. Steel tiedown clevises of 10,000 pounds capacity are bolted at appropriate positions along the rails to provide attaching points for lashings which secure the load to the platform. Dimensions and weight limitations for modular platforms are as follows. The weight is computed at 41 pounds per lineal foot, and the minimum rigged weight is computed at 35 pounds per square foot.

Width (in.)	Length (ft)	Weight (lb)	Square feet	Minimum Rigged Weight (lb)
108	8	328	72	2520
108	12	492	108	3780
108	16	656	144	5040
108	20	820	180	6300
108	24	984	216	7500

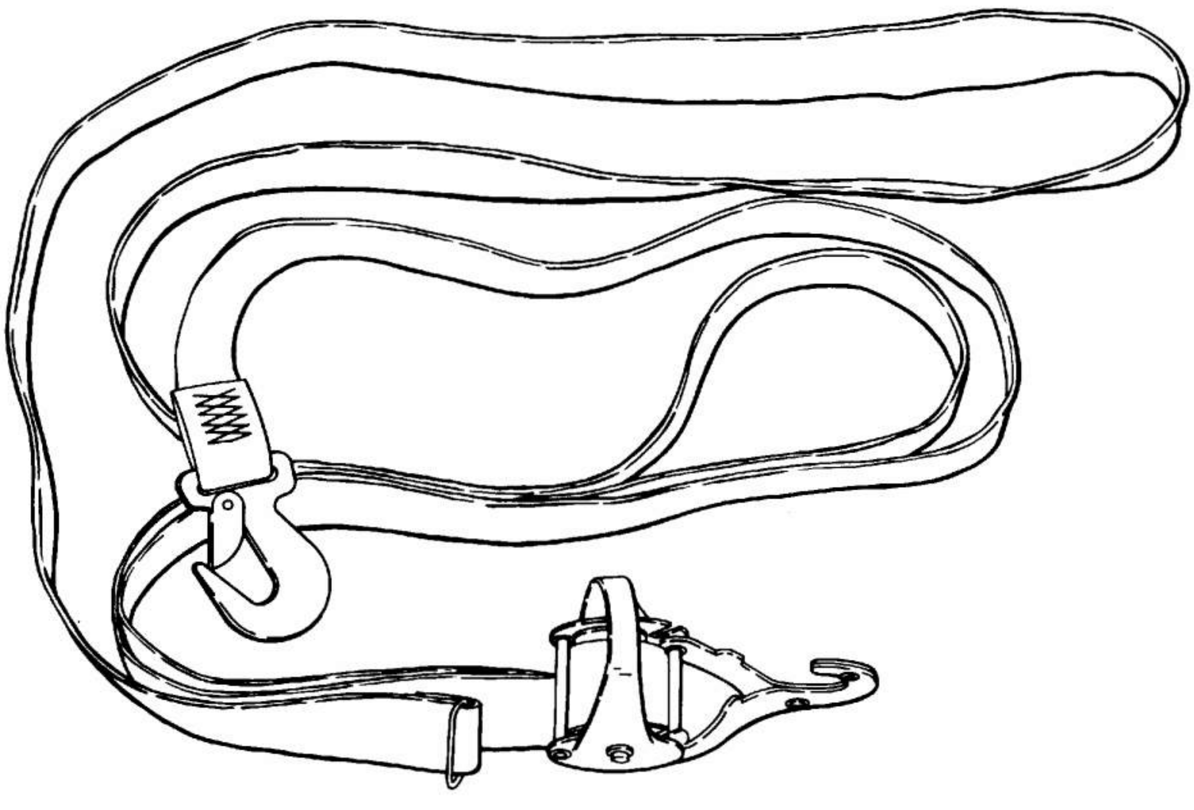


FIGURE 3–58. TIEDOWN ASSEMBLY

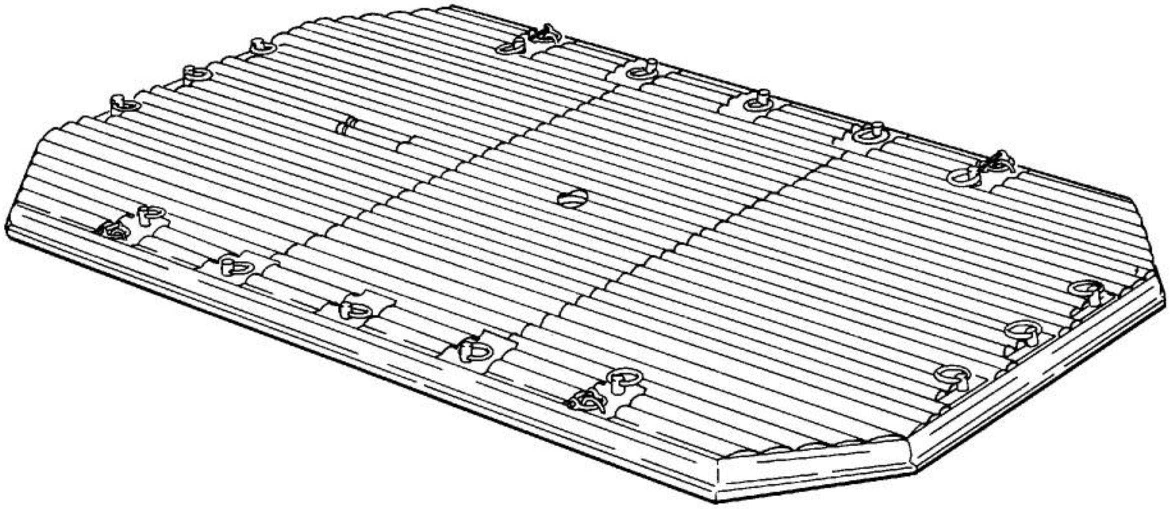


FIGURE 3-59. J-1 PLATFORM

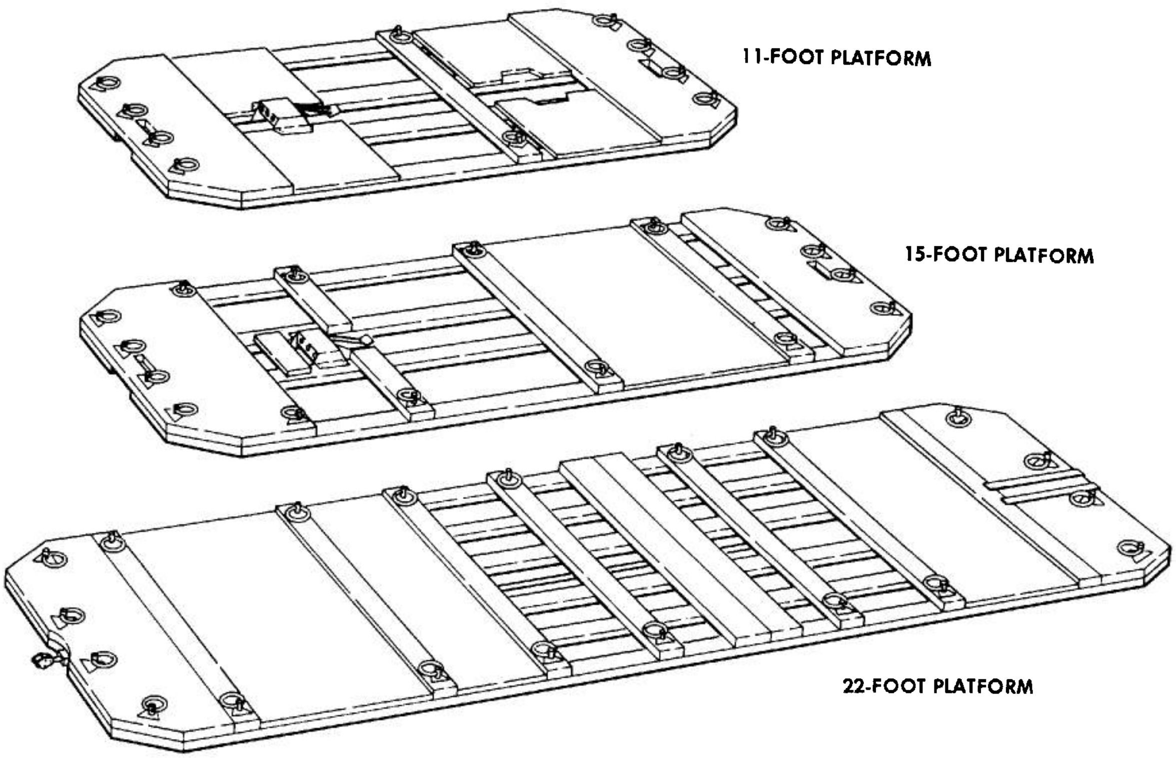


FIGURE 3-60. STANDARD 8 PLATFORMS

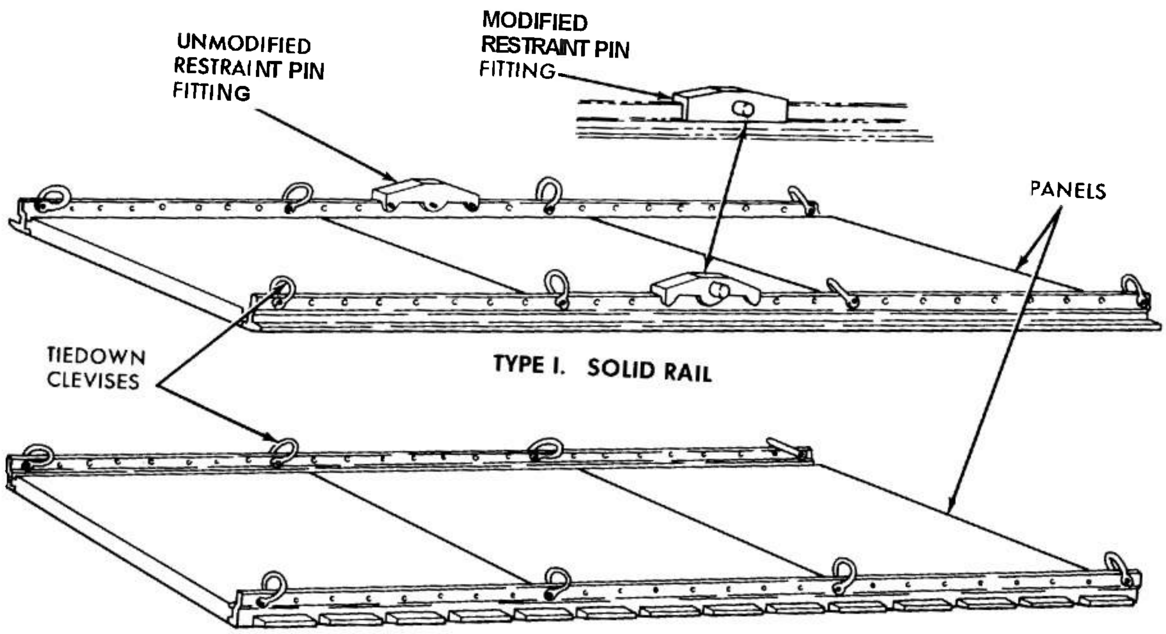


FIGURE 3-67. ALUMINUM MODULAR PLATFORMS

3-18.1.3.2 Wooden Modular *Platform*. The wooden modular platform (Fig. 3-62) weighs about 35 pounds per linear foot (exclusive of cargo tiedown and fixed-pin assemblies), and consists of 4-foot wooden modules and extruded aluminum (6061-T6) side rails of 8-, 12-, 16-, 20-, and 24-foot lengths. A wooden module consists of a plywood sheet, 48 x 95 x 1/2-inch-thick exterior aircraft grade, nailed to three 2- x 6-inch wooden cross members of Douglas fir, structural grade No. 1, with 6d twist nails 2 inches long (pallet nails, type 11, style 18 — Federal Specification FF-N-105). The desired length of platform is made by bolting the required number of 4-foot long wooden modules through three holes at both ends of each 2- x 6-inch cross member to the desired length side rails which have predrilled holes. Attachment is made by 5/16-inch-diameter machine screws 2-1/2 inches long with washers and nuts. The 4-foot wooden modules have aluminum strips (6061-T6), 0.063-inch-thick x 4 inches wide and 52 inches long, positioned so as to align with the inboard conveyor rollers of the C-130 aircraft. The aluminum strips are used to prevent indentation of the bottom face of

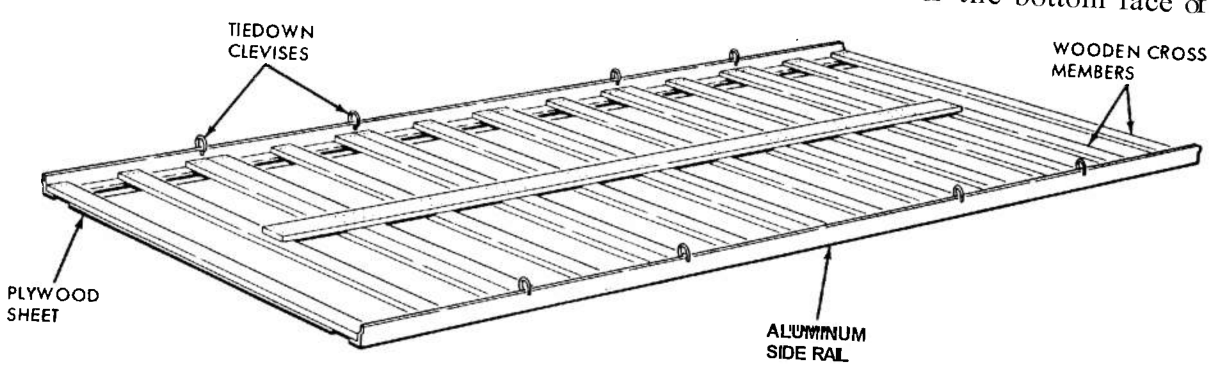


FIGURE 3-62. WOODEN MODULAR PLATFORM

plywood by the conveyor rollers. The aluminum strips are cemented to the plywood bottom face of the module and the extra 2 inches on either end is bent up and nailed to the outer 2- x 6-inch cross members. These aluminum strips are referred to as modular reinforcements. Additional 2- x 6-inch Douglas fir lumber of appropriate length for each specific platform is placed on the centerline of the platform, extends across module joints and is attached with 3-inch long lag screws to the 2- x 6-inch cross members to increase the longitudinal stiffness of the platform when required. Standard tiedown clevises of 10,000-pound capacity are bolted to the aluminum side rails as required for rigging loads. The side rails are notched for use with the USAF A/A32H or C-141 dual-rail systems, and also may be used with the fixed-pin restraint system by attachment of the standard restraint pin fitting to the vertical flange of the aluminum side rail.

3—18.1.4 Combat-expendable Platforms. Combat-expendable platform frames are made of 2-inch thick grade 1 lumber, and the base is made of 3/4-inch plywood (Fig. 3—63). Tiedown spaces are provided on the platform for lashing. Combat-expendable platforms are constructed in a variety of sizes, depending upon the vehicle or item of equipment to be dropped. The suspension and extraction provisions are attached to the item rather than the platform. Table 3—6 lists the dimensions and weight limitations for combat-expendable platforms. These platforms can be used with the skate wheel and buffer board systems.

3—18.2 DESIGN CRITERIA (MODULAR PLATFORMS). The type loading to which a platform is subjected may be classified as ground-handling, inflight-restraint, extraction, recovery, and ground-impact. The characteristics of ground handling and ground impact are often vague, but average conditions can be specified with acceptable accuracy for design purposes[36].

3—18.2.1 Ground Handling. Ground handling is considered to include rigging and transporting-transferring the rigged load into the aircraft.

3—18.2.1.1 Rigging. A platform must be capable of withstanding loads incident to assembly and preparation for rigging by relatively unskilled personnel with little or no materials handling equipment. During rigging, the platform must be capable of sustaining loads imposed on it by the conveyors or uneven terrain on which it may rest. It must also be capable of withstanding loads which result from a rigged payload traversing conveyors. Although selection of a

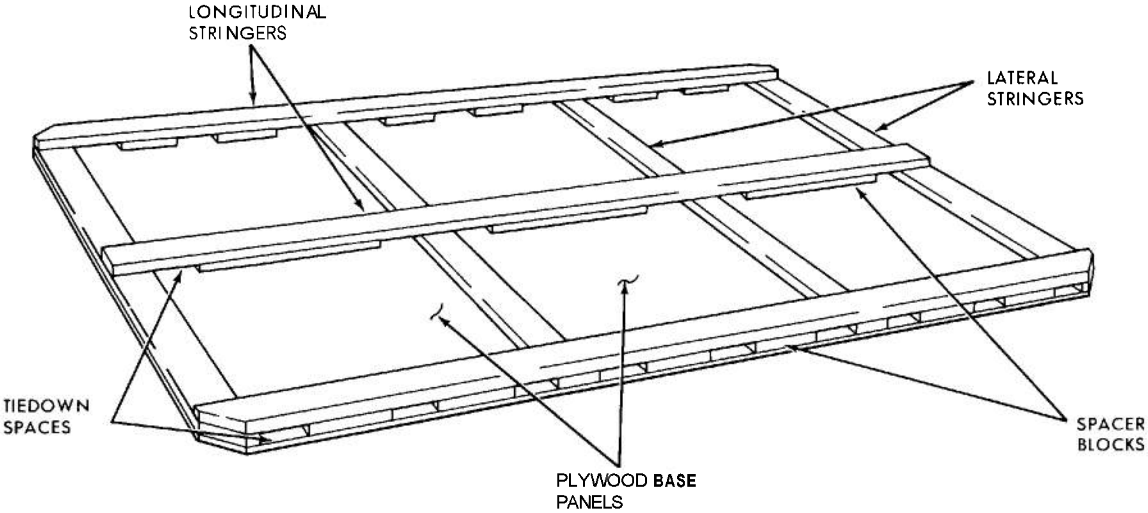


FIGURE 3—63. TYPICAL COMBAT-EXPENDABLE PLATFORM

TABLE 3-6. DIMENSIONS AND WEIGHT LIMITATIONS FOR COMBAT-EXPENDABLE PLATFORMS

LENGTH (ft)	WIDTH (in.)	WEIGHT* (lb)	SQUARE FEET	MINIMUM RIGGED WEIGHT† (lb)
‡12	70	312	70	2450
12	96	407	95	3325
12	104	468	103	3605
12	107	474	106	3710
16	96	480	127	4445
16	104	568	137	4795
16	107	581	139	4865
18	96	643	143	5005
18	104	759	155	5425
18	107	772	160	5600
20	96	709	159	5565
20	104	819	172	6020
20	107	833	177	6195
22	96	815	170	5950
22	104	931	190	6650
22	107	950	195	6825
24	96	877	191	6685
24	104	1048	207	7245
24	107	1068	214	7490

* Figures based on No. 1 common soft lumber
2 x 4 – 1-3/4 pounds per lineal foot
2 x 6 – 2-1/2 pounds per lineal foot
2 x 8 – 3-1/4 pounds per lineal foot
2 x 10 – 4-1/2 pounds per lineal foot

† Size, weight, square footage, and loading weights required for combat-expendable platforms computed at 35 pounds per square foot.

‡ First row pertains primarily to CV-2 aircraft.

specific design condition must be a matter of judgment based on experience, a condition can be chosen which strikes an acceptable balance between performance and the resulting structural penalty. Of course, with any such compromise, there will occur an occasional extreme instance such as when the entire rigged weight of a load may teeter on the edge of a single roller, thus exceeding the selected design condition and resulting in platform damage. A useful design condition is shown in Fig. 3–64, the variables being the force P, the length and diameter of the rollers, and the pitch between rollers. The configuration of the aircraft roller conveyors, the load distribution on the platform, and the pertinent load factor determine the values of these variables. For sandwich construction, the structural details directly influenced by the ground handling design condition are principally facing thickness, and material and

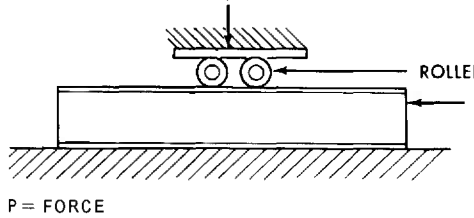


FIGURE 3–64. DESIGN CONDITION FOR GROUND HANDLING

core compressive strength. *Also* under the category of ground handling is a design requirement for a measure of stiffness far in excess of that needed for inflight restraint. Large deflections during rigging due to high tensions in lashings can compound the difficulties in traversing roller conveyors with or without platform damage and can make it impossible to properly engage the aircraft dual-rail restraints.

3—18.2.1.2 Transporting-Transferring into Aircraft. A platform must be capable of withstanding loads incident to transporting-transferring it, with payload, from the rigging site into the aircraft. The loads occur during lifting or winching onto a transport vehicle, while transporting over rough terrain, and during the actual transfer into the aircraft. The transport-transfer vehicle(s) does not always lie in the same plane as that of the aircraft floor, and therefore high localized reactions on the platform are often experienced during the transfer.

3—18.2.2 Inflight Restraint. This category of loading includes restraint of the platform to the aircraft and payload to the platform to the following ultimate load factors[21].

Forward	4.0 g's
Aft	1.5 g's
Vertical (up)	2.0 g's
Vertical (down)	4.5 g's
Lateral	1.5 g's

The strength of the local structure needed to restrain the platform load to the aircraft and also the load to the platform is readily established. Since the longitudinal edges of the platform mate directly with the aircraft dual rails, it follows that confining the restraint attachments and the cargo tiedown rings to these edges is an effective solution to minimizing the amount of platform structure needed. Even though tiedown points are not available on the lateral edges of the platforms, rigging ease and effectiveness can be assured by providing a large number of high capacity unit tiedown points along the longitudinal edges.

Of the inflight factors, the forward load factor has the most influence on platform design. The aft load factor also requires consideration of those aircraft rail-systems which provide aft restraint only in the left restraint rail, resulting in an asymmetric loading on the platform. This load condition could be critical for some platform structures.

Once provision has been made for the high local loads associated with platform-to-aircraft and payload-to-platform restraint, consideration of the other loading conditions included herein indicates selection of a sandwich construction for the platform to be a wise, and possibly inescapable, choice. The favorable strength-to-weight and strength-to-cost ratios which can be obtained with a properly designed sandwich construction are the primary reasons for such a choice.

When the inflight restraint and ground handling design conditions have been satisfied, experience indicates that with attention to a few localized areas, acceptable reuse can generally be obtained. High localized stresses at ground impact are often induced at the intersections of platform lateral and longitudinal frame members and in the fastening of the facings to the peripheral frame members in sandwich construction. Simple reinforcements at these locations contribute measurably to platform reuse.

3—18.2.3 Extraction. The force of the extraction parachute is applied either to the platform or directly to the payload itself. When the extraction force is applied to the platform, localized platform structure of sufficient strength is required to withstand the extraction force. This case results in inertial forces due to the acceleration of the payload being applied to the platform through the cargo tiedowns. When the extraction force is applied to the payload, the forces applied to the platform by the tiedowns are opposite in direction and usually of much less magnitude than in the case of platform extraction. This is due to the fact that the only mass being accelerated through the tiedowns is that of the platform itself. The ratio of extraction force to extracted weight with the dual-rail system is usually maintained between 0.7 and 1.5. The design load (ultimate) is taken as 1.5 times this ratio[5]. The applied force is appropriately treated as a static load because of the emergency situation where the system may malfunction, resulting in the extraction parachute being towed for several seconds. In the normal case, the duration is also quite long (Fig. **3—65)** and is probably sufficient justification itself to design to the static load. However, devices which are used to transfer the extraction force from the platform to the recovery parachutes operate over a very short period of time and therefore should be designed and laboratory-tested with the dynamic nature of their operation in mind.

3—18.2.4 Recovery. As in the case of extraction, the forces exerted by recovery parachutes may be applied either to the platform or directly to the payload itself. Because of the magnitude of the forces associated with the opening of cargo parachutes and the vagaries of platform attitude relative to the direction of the forces, the case of parachute recovery forces applied to the platform entails a requirement for considerably more platform structure than where these forces are applied to the payload. In the latter case, the forces imposed on the platform through the cargo tiedowns are proportional only to the mass of the platform itself and whatever other material (such as accompanying supplies) is not directly attached to or supported by the payload. In the case of most large vehicles, the general practice is to take advantage of their inherent strength and suspend them directly from the parachutes. In keeping with this practice, the platform is suspended from the parachutes only when the payload is of such a nature that it cannot readily be suspended itself. The magnitude of the limit load factor used for design is 3.0 times the weight of the suspended load. For design purposes, the resultant forces are considered to be shared equally by any two of what are normally four suspension points and are treated as static loads. As is the case for extraction, a factor of safety of 1.5 is used to obtain the ultimate loads. The typical trace (Fig. **3—66)** shows the long duration of the parachute opening shock. Credible data recently obtained from actual airdrops indicate that the criteria stated above err on the conservative side. Considerably more evidence will be required, however, to justify a reduction in these criteria under the critical design extremes of airspeed, platform attitude, and parachute loading.

3—18.2.5 Ground Impact. The forces to which a platform is subjected at ground impact cover a wide range in nature and magnitude. The variables affecting these forces include:

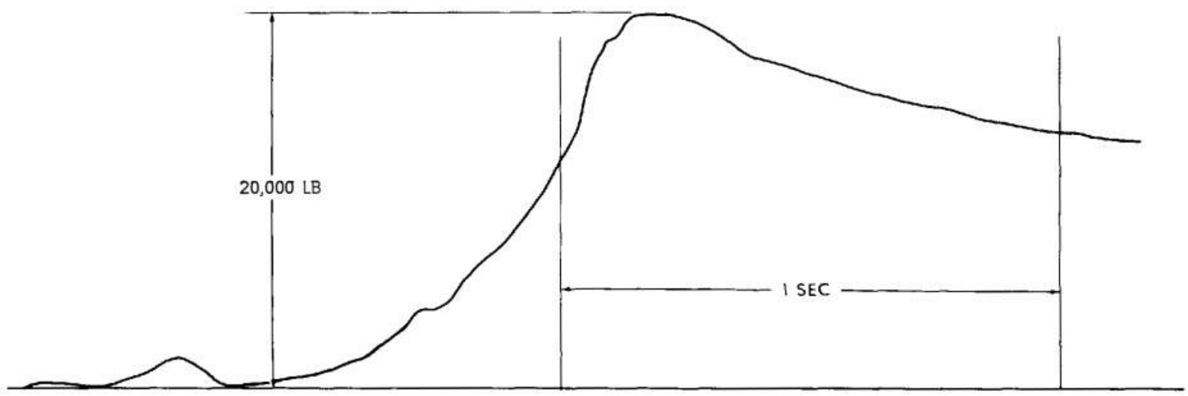


FIGURE 3-65. TYPICAL TRACE OF EXTRACTION FORCE VS TIME

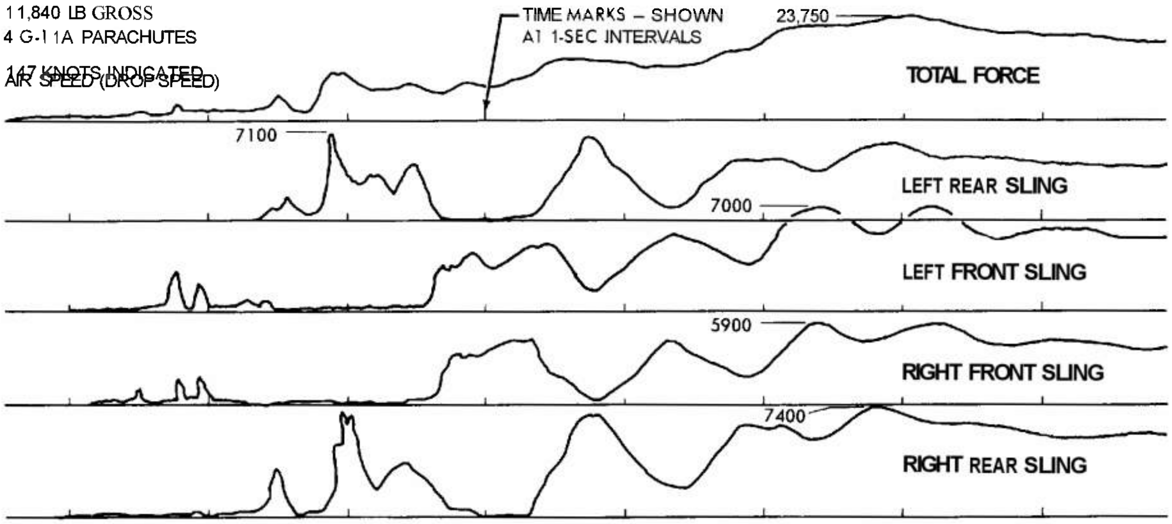


FIGURE 3–66. TYPICAL TRACE OF SUSPENSION FORCES AT PARACHUTE OPENING

a. Vertical velocity

b. Horizontal velocity

c. Size and placement of payload and cushioning material

d. Platform attitude

e. Consistency of impact surface

f. Irregularities in terrain

g. Type and geometry of cargo lashings

In actual practice, the forces imposed on the platform may be dependent on the interaction of all the variables listed. Designing a platform to be reusable under the operational extremes of all these variables is simply not practical. However, a design condition reflecting certain of these variables can be selected which results in acceptable reuse. This condition may be expressed in practical terms as cantilever length L, applied force P, and direction of force (angle θ) as shown in Fig. 3–67.

Environmental requirements should be borne in mind throughout the design. Not only must a platform maintain structural integrity during long-term exposure to extremes of temperature, humidity, and harmful bacteria or vermin, but it must also maintain dimensional stability within fairly close limits because of the nature of the aircraft dual-rail system. These considerations are likely to dictate the final selection of materials and methods of manufacture.

3–19 CONTAINER GROUP

3–19.1 General. Container loads are loads that are rigged for airdrop in airdrop containers such as the A-7A cargo sling, the

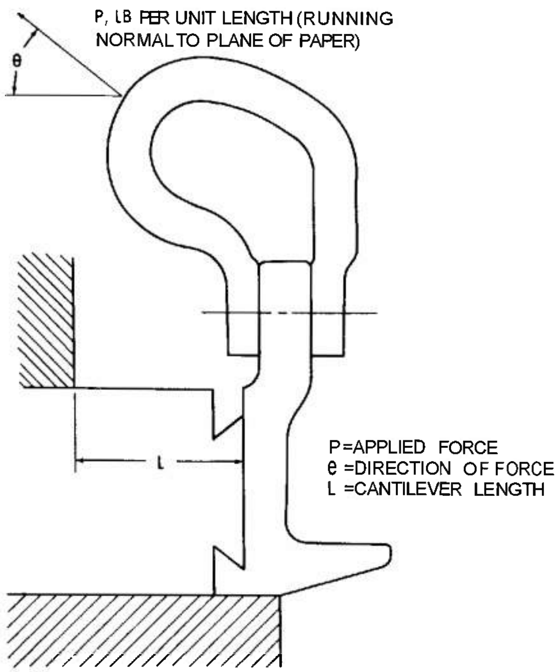


FIGURE 3–67. DESIGN CONDITION FOR GROUND IMPACT

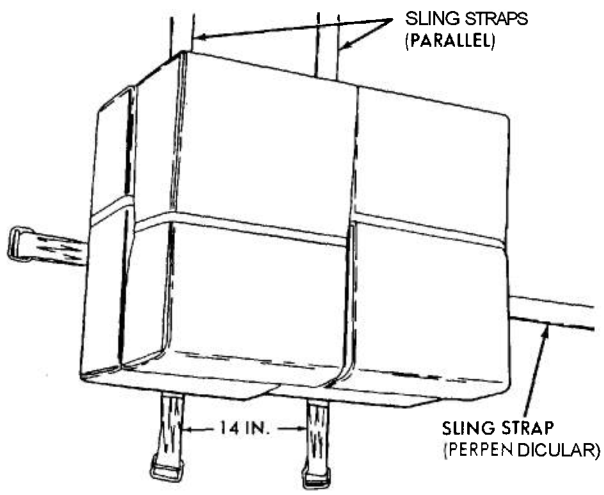
A-21 and A-22 cargo bags, and the M4-A high speed aerial delivery container. In addition, flat steel strapping may be used to rig container loads. The containers may be packed with supplies, disassembled equipment, or small items of ready-to-use equipment prepared for airdrop. The container load may require cushioning material such as honeycomb, depending upon the load requirements and the method of airdrop. The load may require one or more pilot chutes or one cargo parachute to stabilize and retard the descent of the load, depending upon the weight of the load and the method of airdrop. The containers are prepared and packed for airdrop according to procedures in TM 10-500[7]. Rigging of containers for airdrop is contained in applicable TM 10-500 series manuals.

3—19.2 TYPES AND SIZES

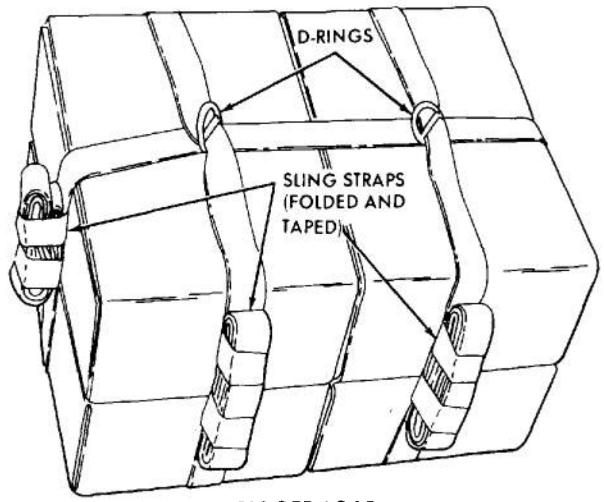
3—19.2.1 Cargo Sling (A-7A). The A-7A cargo sling (Fig. 3—68) consists of four identical sling straps, each 188 inches long. Each sling strap is fitted with a quick-fit strap fastener and a floating D-ring. A combination of two, three, or four sling straps may be used for rigging a load in an A-7A cargo sling, depending upon the size and shape of the load. The A-7A cargo sling has a 500-pound capacity. It is designed and constructed in accordance with USAF Drawing 51C6716 and conforms to Military Specification MIL-C-7554.

3—19.2.2 Cargo Bag (A-21). The A-21 cargo bag (Fig. 3—69) is an adjustable container consisting of sling assembly, quick-release assembly, two ring straps, and canvas cover. The A-21 cargo bag has a 500-pound load capacity. It is designed and constructed in accordance with USAF Drawing 51C6739 and conforms to Military Specification MIL-C-7554.

3—19.2.2.1 Sling Assembly. The sling assembly (Fig. 3—69) consists of a sling, three quick-release straps, and one fixed quick-release strap. The sling is made of webbing with an octagonal scuff pad attached. One 188-inch main strap is stitched lengthwise on the scuff pad and two 144-inch side straps are stitched crosswise. Four lifting handles or loops are stitched to the side straps to facilitate handling of the loaded container. The V-rings are attached to the main strap and are extended through to the underside on the scuff pad. These V-rings are sometimes used when loads are dropped by the monorail system. The quick-release straps are fitted at one end with a quick-fit strap fastener to secure them to the side straps of the sling, and at the other end with connecting lugs to attach the release straps to the quick-release assembly. The fixed quick-release

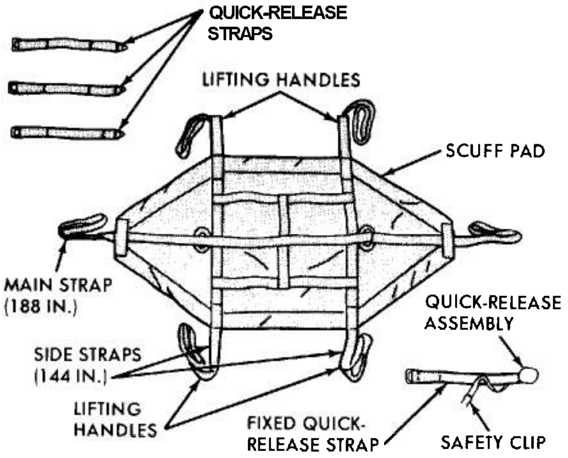


LAYOUT OF SLING STRAPS

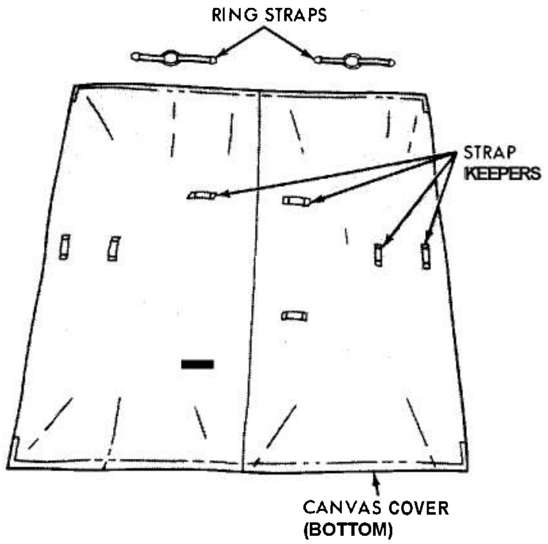


RIGGED LOAD

FIGURE 3-68. TYPICAL A-7A CARGO SLING LOAD USING THREE SLING STRAPS



SLING ASSEMBLY AND QUICK-RELEASE ASSEMBLY



RING STRAPS AND CANVAS COVER

FIGURE 3-69. CARGO BAG (A-211

strap, which remains connected to the quick-release assembly once it is attached, is also fitted with a permanently attached quick-release safety clip. The safety clip fits into the telease assembly to prevent it from opening accidentally.

3—19.2.2.2 Quick-release Assembly. The quick-release assembly (F'ig. 3—69) is designed to secure the load in the container and to permit quick removal of the sling assembly once the cargo reaches the ground. The sling assembly may be released from the load by removing the safety clip from the release assembly, turning the release operating button clockwise, and pressing the button down until the quick-release straps are free.

3—19.2.2.3 Ring Straps. Each of the two ring straps (F'ig. 3—69) consists of a long strap and a short strap attached to a steel rod ring. The long strap is fitted with a quick-fit strap fastener to secure it to one end ,of the main strap of the sling. The short strap is fitted with a D-ring to provide a means of attaching the parachute to the load.

3—19.2.2.4 Canvas Cover. The canvas cover (Fig. 3—69) is provided with eight strap keepers to hold the main strap and the two side straps of the sling.

3—19.2.3 Cargo Bag (A-22). The A-22 cargo bag (Fig. 3—70) is an adjustable cotton duck cloth and webbing container consisting of sling assembly, cover, four suspension webs, and skid. The A-22 container generally conforms to Military Specification MIL-C-6346A and has a 2200-pound maximum load capacity. Except for the Container Delivery System (CDS), the minimum load of the container is 700 pounds for containers up to 52 x 54 inches and 820 pounds for containers of 52 inches laterally and over 54 inches up to and including 65 inches longitudinally[44]. 'A-22 containers are designed and constructed in accordance with USAF Drawing 50B7702.

3—19.2.3.1 Sling Assembly. The sling assembly (Fig. 3—70) consists of a network of webbing attached to a rectangular scuff pad. The quick-fit strap fasteners secure the lateral straps around the load. The D-rings on the support webs provide points of attachment for the four suspension webs.

3—19.2.3.2 Cover. The cover (Fig. 3—70) is made from two rectangular panels of cotton duck cloth sewed together at right angles. The square formed by the intersection of the panels equals the dimensions of the scuff pad of the sling assembly. Sixteen lacing loops on the outside of the panels provide for the lacing cords which secure the cover panels at the corners of the load.

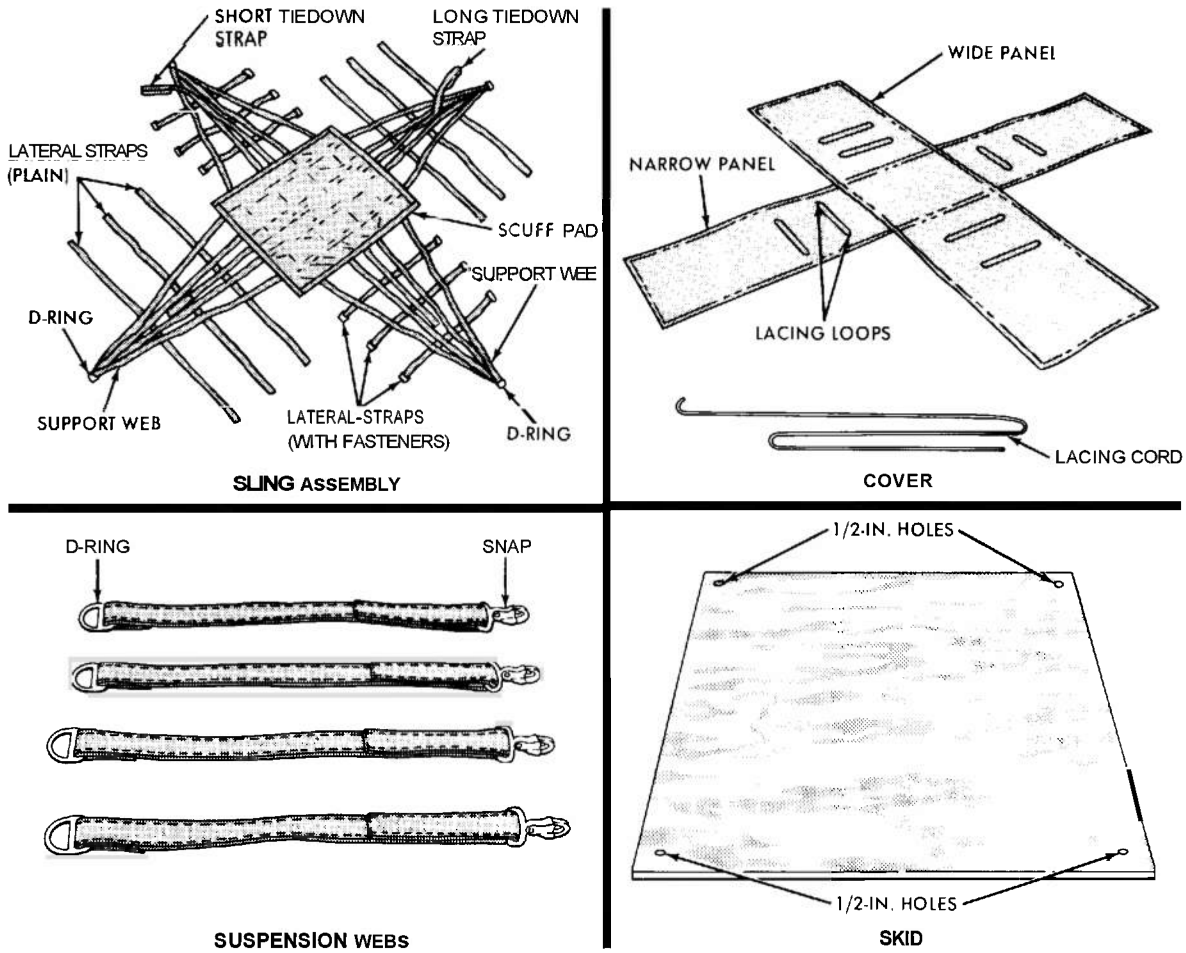


FIGURE 3–70. CARGO BAG (A-22)

3—19.2.3.3 Suspension Webs. The four suspension webs (Fig. 3—70) are used to attach the container and load to the parachute.

3—19.2.3.4 Skid. The skid (Fig. 3—70), which serves as a base for the container load, is fabricated locally from 1/2- or 3/4-inch plywood. A 1/2-inch hole is drilled at each corner of the skid, 2-1/2 inches in diagonally from the corner. The size of the skid may vary depending upon the dimensions of the load, but it must not exceed 52- by 54-inch measurements[7]. The most economical skid for the cargo bag is 48 by 48 inches. Larger plywood bases with shock-absorbing honeycomb are often used if an airdrop is planned that will have a high rate of descent caused by using a 15-foot or 22-foot ring-slot parachute.

3—19.2.4 Steel Strapping. The steel strapping commonly used for rigging airdrop loads is made of flat steel 0.020-inch-thick, 5/8-inch-wide, with a breaking strength of 1000 pounds. The steel strapping may be used as a container, in combination with webbing straps, or to bind items of equipment together for packing in container loads. When steel strapping is used as the container, the load limit is 250 pounds and the steel strapping is of double thickness.

3—19.2.5 High Speed Aerial Delivery Container (M-4A). The M-4A container (Fig. 3—71) is constructed of aluminum. The semicircular logitudinal sections joined together with a piano hinge and rod make up the cargo compartment of the container. The cargo compartment is closed at either end by

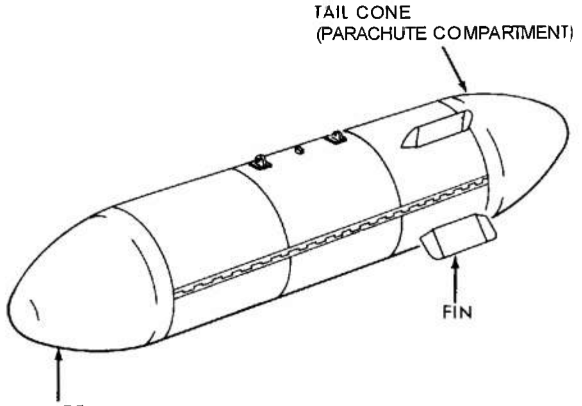


FIGURE 3-71. HIGH SPEED AERIAL DELIVERY CONTAINER (M-4A)

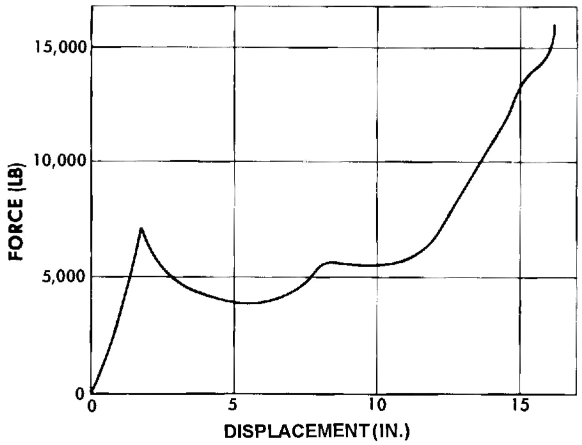


FIGURE 3-72. DYNAMIC FORCE-DISPLACEMENT CURVE OF M-4A NOSE CONE

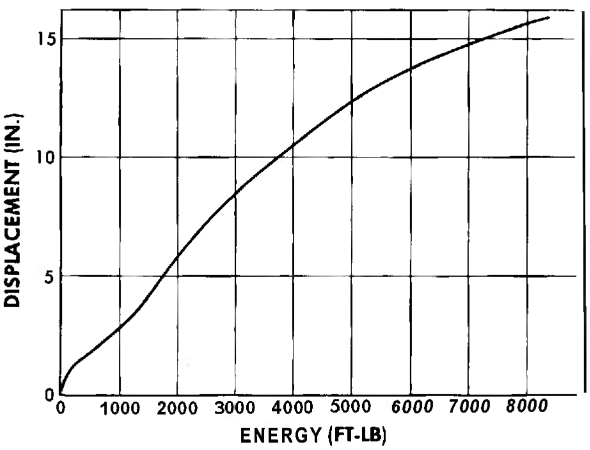


FIGURE 3-73. DYNAMIC ENERGY-DISPLACEMENT CURVE OF M-4A NOSE CONE

removable forward and rear plywood bulkheads that fit into slotted sections of angle aluminum. A 34-foot ring-slot parachute is packed into a recessed area adjacent to the tail cone. Four removable aluminum fins located at the rear of the container are provided for stabilizing the container during descent. Four carrying straps are also provided. Length of the container, including nose and tail cone, is 109-3/4 inches and its total weight is 110 pounds. The inside dimensions are 21 inches in diameter and 61 inches in length. The nose and tail cones, which are identical, have a base diameter of 21 inches and a height of 20-5/8 inches. The M-4A container is presently authorized to be carried under the wings of aircraft at speeds up to 550 knots and can be released at speeds up to 300 knots. After the container is dropped, a parachute is deployed that lowers the container to the ground. Energy of impact is absorbed by the crushing of the nose cone[31]. Dynamic force-displacement and energy-displacement curves of the nose cone are presented in Figs. 3-72 and 3-73. The nose cone can absorb approximately 11,700 foot-pounds of energy before bottoming (a maximum crush of approximately 18 inches). Paper honeycomb can be placed inside the container as an additional energy absorber.

3-20 ENERGY DISSIPATION GROUP

In the process of air delivery, the item to be airdropped is subjected to four different loading environments of which ground impact is the final and most severe. The energy dissipating system is designed to reduce the impact on ground contact to within permissible limits through the use of cushioning materials.

3-20.1 CUSHIONING MATERIALS. In the selection of cushioning materials, the concern is dissipation of energy during a single impact. Recovery of deformation after loading is not required and, in fact, is undesirable since it produces rebound after impact. The stress-strain curve for a material reveals much about its ability to carry a given load, to deform under load, and to dissipate energy. Figure 3-74 compares the stress-strain curve of paper honeycomb with that

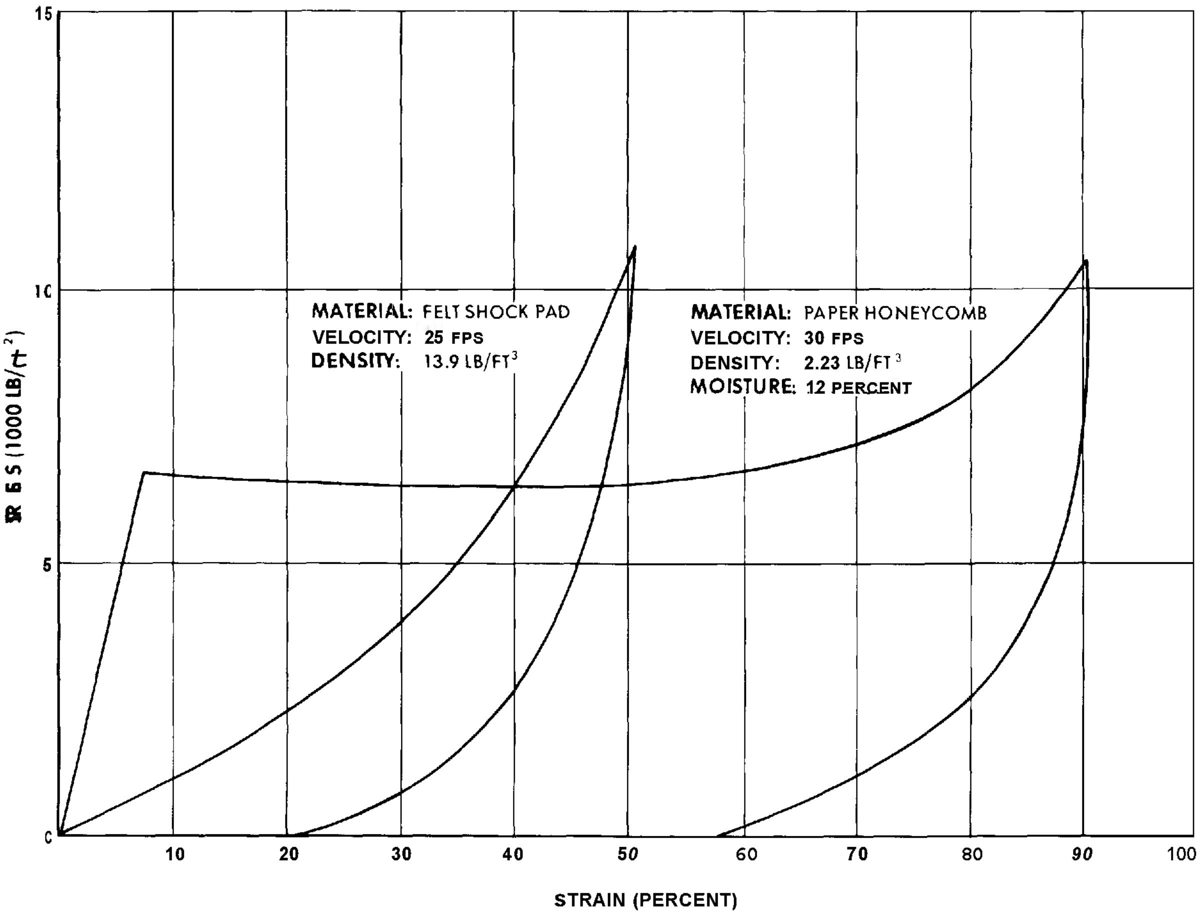


FIGURE 3–74. STRESS-STRAIN CURVES FOR PAPER HONEYCOMB AND FELT SHOCK PAD

of previously used felt shock pad. The materials described below have been evaluated as energy dissipaters.

3–20.1.1 Paper Honeycomb. Research at The University of Texas has proven paper honeycomb to be acceptable in all respects as an energy dissipater in the airdrop of equipment[22]. Approximately constant stress levels, with the exception of an initial peak, may be expected up to 70-percent strain under both dynamic and static conditions (Fig. 3–75). Under dynamic loading, the stress and energy-absorption values are considerably larger than those for static loading. For practical cushion design, no appreciable difference in stress-strain characteristics occurs with a variation of impact velocity from 30 feet per second to 90 feet per second, and moisture content of less than 10 to 12 percent does not modify the dynamic cushioning characteristics appreciably. Paper honeycomb conforming to class 3, style A, of Military Specification MIL-H-9884A is the material currently used in energy dissipating systems. This material crushes at an essentially constant dynamic stress of 6300 pounds per square foot, ± 900 pounds per square foot through zero to 70 percent strain. It is available in thicknesses of 1/2, 1, 2, 3, and 4 inches, and in sheet sizes of 36 by 48 inches, 36 by 96 inches, 48 by 48 inches, and 48 by 96 inches. A commercially available paper honeycomb material, designated as 80-0-1/2, expanded, double-faced, 3-inch thick panel, is a functional substitute of the military item.

3–20.1.2 Foamed Plastics. Many foamed plastics have been tested to determine their energy absorption characteristics[23,24].

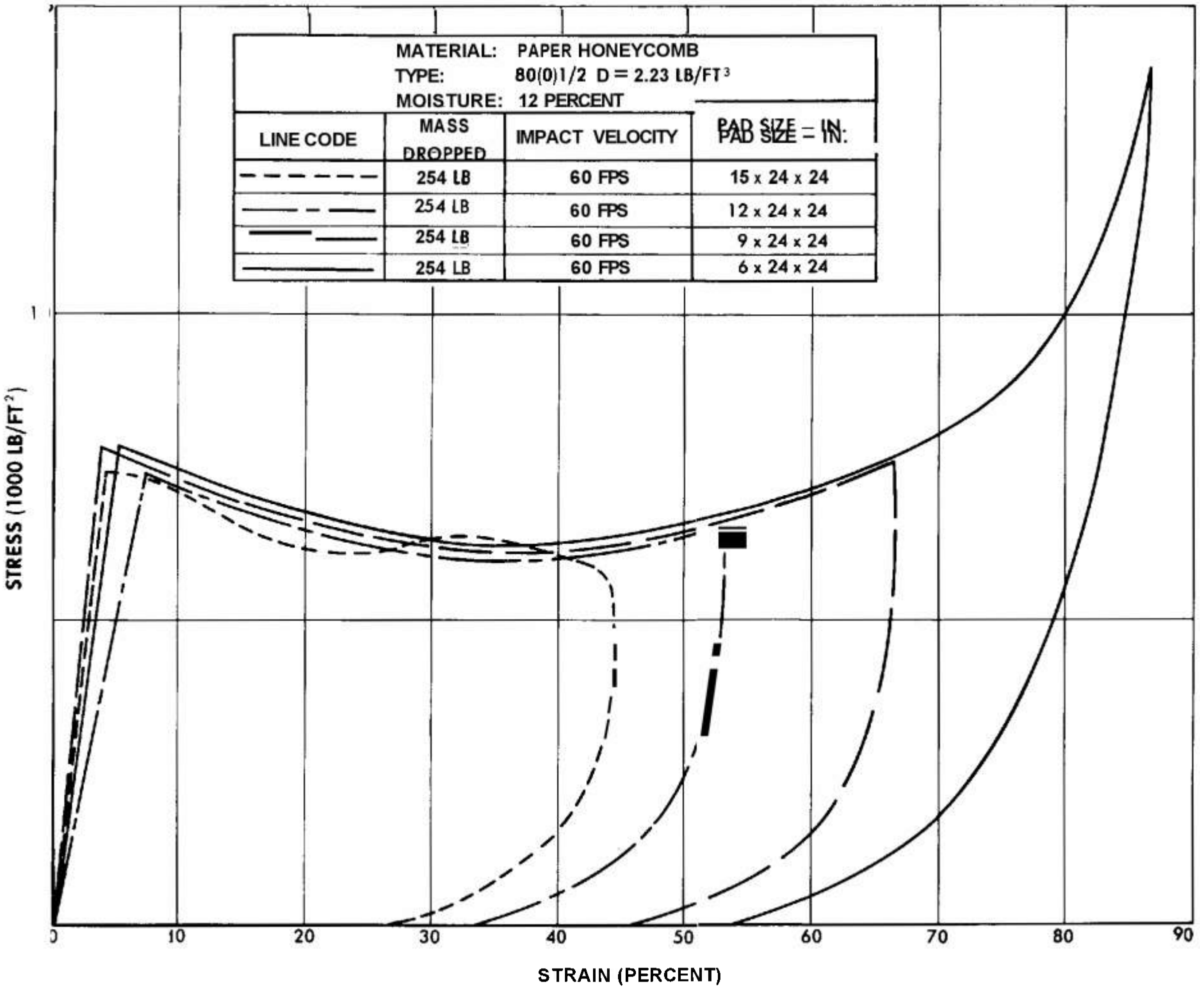


FIGURE 3–75. STRESS-STRAIN CURVES FOR PAPER HONEYCOMB WITH MINIMUM STRAIN VARIED

The dynamic stress-strain curve for a polyurethane foamed plastic, using various densities of foam, is shown in Fig. 3–76. This plastic does not produce a pronounced initial peak stress; however, it does begin to bottom at approximately 50 percent strain— as compared to 70 percent for paper honeycomb —indicating a much lower optimum strain. This would necessitate using more material for dissipating a given amount of energy. In general, although foamed plastics exhibit an efficient stress-strain curve and have the advantage of being highly resistant to environmental conditions, excessive cushioning costs — due to the amount of material required and the cost of production— limit their use as an energy dissipater.

3–20.1.3 Metal Cylinders. The walls of a thin-walled metal cylinder will buckle when subjected to an axial compressive load, thereby dissipating impact energy. Filling the cylinder with fluid and providing holes for the fluid to escape during compression will aid in energy dissipation. Tests have indicated metal cylinders to be feasible energy dissipaters for special conditions, such as a concentrated or point impact load[25].

3–20.1.4 Other Materials. Various additional materials have been tested for use as energy dissipaters[26]. Some, such as aluminum honeycomb, are comparable to foamed plastic in that they exhibit suitable cushioning characteristics for general use within certain limited areas. Others, such

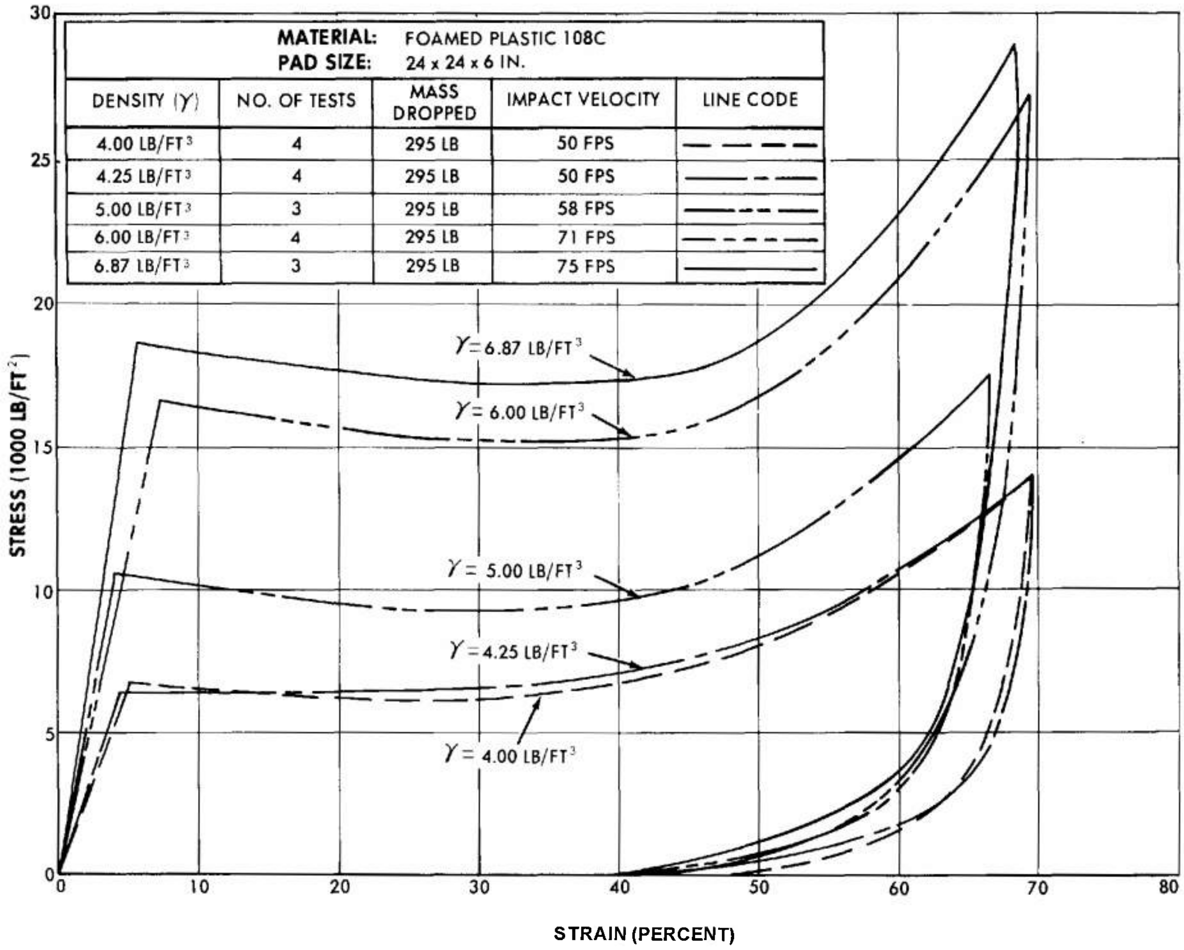


FIGURE 3–76. EFFECT OF DENSITY ON STRESS-STRAIN CURVES FOR POLYURETHANE FOAMED PLASTIC

as wood under lateral compression[27], proved suitable for special-purpose application.

3—20.2 DESIGN CRITERIA OF DROPPED ITEM. The requirement for airdrop capability must be given consideration during the design phase. MIL-STD-669A[28] lists detailed technical airdrop design criteria for use in the development of military equipment having an airdrop requirement. The design of an energy dissipation system is affected in many ways by the design of the item being dropped. The ability of the item to withstand the stress of deceleration at impact is a primary concern. Another design factor to consider is the ability of the bottom area of the item to conform to an energy dissipation system (projections, nonrigid members, etc). Also components attached by nonrigid mounts, such as engines, compressors, etc., must be considered.

3—20.3 ASSOCIATED EQUIPMENT

3—20.3.1 Load Spreaders. When dropping items having an irregular bottom surface, it may be necessary to use load spreaders to distribute the load over the entire dissipater area. *Also,* when using small stacks of paper honeycomb, load spreaders may be used to distribute the force over several stacks or, on vehicles, to distribute the force along the stronger frame members (Fig. 3—77). Load spreaders are usually cut from 3/4-inch plywood. The load spreader must be glued to the top layer of paper honeycomb.

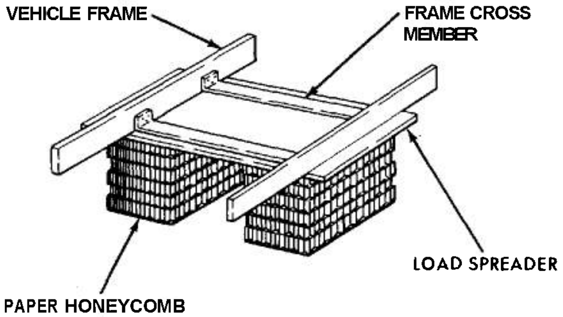


FIGURE 3-77. LOAD SPREADERS USED IN VEHICLE ENERGY DISSIPATING SYSTEM

3-20.3.2 Paper Honeycomb Expanders. Paper honeycomb conforming to class 1 of Military Specification MILH-9884A (unfaced, unexpanded) must be expanded, and facing paper applied, before it is ready for use. Hand- and power-operated expanders are available. A power-operated expander will process unfaced, unexpanded pads of untrimmed paper honeycomb by expanding it to a width of 36 inches and a height of 3 inches at the rate of 300 lineal feet, or thirty-seven 8-foot panels, per hour. The expander will automatically apply facing paper, coated on one side with heat-sealable polyethylene, to both sides of the expanded paper honeycomb.

SECTION IV

AIRDROP SYSTEM TECHNOLOGY

5-21 GENERAL

Operational requirements for airdrop systems are continually expanding, necessitating a concurrent advancement of the state-of-the-art in airdrop systems design. It is the task of the designer, utilizing both proven and theoretical design criteria, to provide systems designs which appear analytically to have the best chance of attaining the necessary performance requirements. However, airdrop systems performance parameters are subject to conditions of application which, in the end, may be so diverse that the determination of the success with which the designs are carried out usually becomes a matter for statistical evaluation over a considerable period of time. Thus, when designs are completed and the drag device and associated components manufactured, tests must be conducted to verify their performance and design characteristics. This section presents the operational characteristics of standard airdrop systems and the aerodynamic considerations necessary to allow determination of parachute type and size. An analysis of the airdrop operation is presented in paragraphs 3—24 through 3—29. Airdrop testing is presented in paragraph 3—30.

3—22 PARACHUTE AERODYNAMICS

Knowledge of the aerodynamic and operational characteristics of parachutes is one of the major prerequisites for the design and performance prediction of dependable airdrop systems. In selecting a particular parachute type to perform a specific airdrop task, the characteristics of the parachute itself must be known, so that its performance in combination with a primary load — as a system — can be predicted. At the present time, sufficient knowledge is not available to provide analytical approaches for the calculation of all performance and operational characteristics of parachute canopies; thus, experimental data must be relied upon. However, in some areas analytical approaches have been developed which will yield reasonable approximations of the characteristics of actual parachute performance. These approaches are presented in DDC Document No. AD429971, ***Performance of and Design Criteria for Deployable Aerodynamic Decelerators***[18]. It must be pointed out that these analytical approaches are initial attempts in developing calculation methods, and that these approaches are subject to revision as new knowledge becomes available. This knowledge will then be utilized to either verify, augment, or completely revise the method of analysis. However, the results obtainable by the analytical methods presented in Reference 18 are, in most cases, reasonably accurate and may be utilized for the determination of textile parachute canopy and airdrop systems performance and operation.

3—23 CHARACTERISTICS OF STANDARD AIRDROP SYSTEMS

3—23.1 STANDARD AIRDROP SYSTEMS LIMITATIONS. The following limitations apply to current standard airdrop systems. Research being conducted to extend airdrop capability will cause frequent revision of these limitations as new methods and materials are developed.

a. The current standard airdrop systems are designed to function properly at airdrop speeds up to 150 knots. Present airdrop operations, however, are limited to lower airdrop speeds, the highest being 130 knots.

b. A standard airdrop altitude of 1100 feet above the highest terrain on the drop zone is presently being used. The advantages of low-altitude airdrop are prompting the development of new systems for this use.

c. Airdrop with the current systems is normally restricted to wind speeds below **15** knots.

d. The maximum rate of descent specified for current systems is 28.5 feet per second. This rate of descent is based on 100°F at an altitude of 5000 feet. Some items, such as ammunition, are adaptable to high-velocity container drops at 70 to 90 feet per second.

e. Heavy equipment drops can be made with unit load weights of from 2500 to ***35,000*** pounds. Single- and multiple-platform airdrops can be made up to the design limits of the aircraft.

3—23.2 EXTRACTION FITTING CRITERIA. Extraction provisions and related attachments are provided for attachment of the extraction system. Standard vehicle pintles or tow bar attachments may be used for this purpose if they meet the requirements of **MIL-STD-814A**[5] and if the airdropped item has a gross rigged weight of less than 25,000 pounds. The opening in the extraction fitting must be a minimum of **1-1/ 16** inch in diameter, with the centerline at least **1.375** inch from the airdrop item. The dimensional requirements for extraction fittings are shown in Fig. 3—78. The limit load capacity **of** extraction fittings shall be 1.5 times the gross rigged weight. The yield strength shall be a minimum of 1.5 times the limit load. The ultimate load capacity for extraction fittings used on **a** rigged load weight of less than 25,000 pounds shall be a minimum of **1.65** times the limit load. If the rigged load weight is greater than 25,000 pounds, the ultimate load capacity shall be a minimum of 1.75 times the limit load. These limits are determined with forces applied in the direction shown in Fig. 3—79. Extraction provisions are normally located on the longitudinal centerline and below the center of gravity.

3—23.3 SUSPENSION FITTING CRITERIA. Suspension fittings are provided for attachment of the retardation system to an item. The suspension fittings are limited to the dimensions shown in Fig. 3—80[5]. The centerline **of** the holes will be either at right

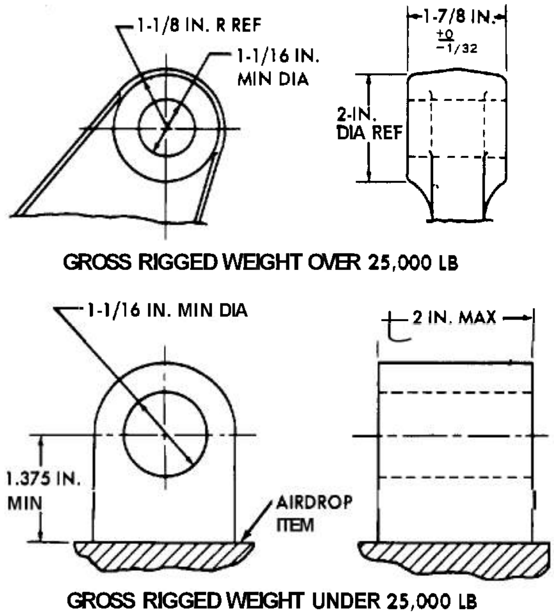


FIGURE 3–78. EXTRACTION FITTING DIMENSIONAL REQUIREMENTS

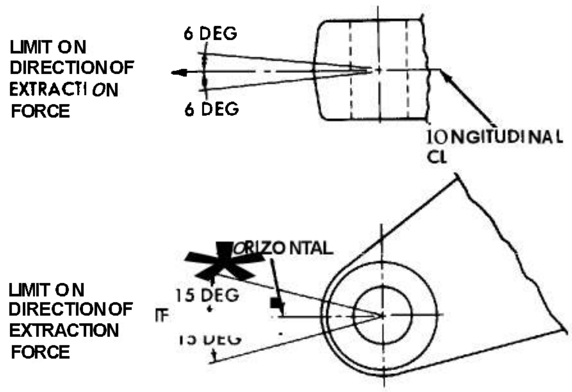


FIGURE 3–79. DIRECTION OF LOADING FOR EXTRACTION FITTINGS

angle with the longitudinal centerline of the dropped item, or, to minimize bending loads, oriented to match the suspension sling and clevis geometry. The limit load of each suspension fitting shall be **1.5** times the suspended weight. The yield strength shall be 1.5 times the limit load. These limits are determined with forces applied in any direction. Four suspension fittings are required for each airdrop item. The fittings should be located as far apart as practicable. Wherever possible, they should be centered in a rectangular pattern about the vertical axis through the center of gravity

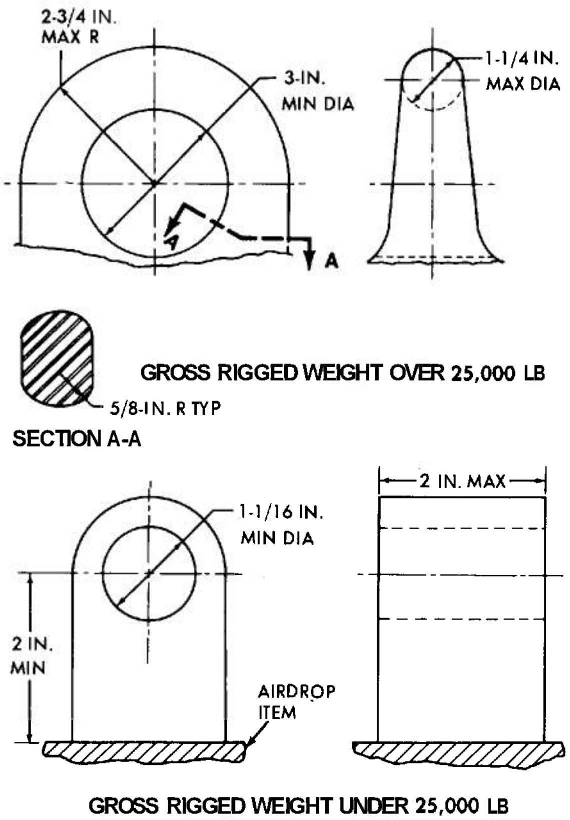


FIGURE 3–80. SUSPENSION FITTING DIMENSIONAL REQUIREMENTS

of the suspended load. Also, they should be located above the horizontal plane passing through the center of gravity of the load at a height such that interference between suspension slings and the item is minimized. The use of spreader bars is not authorized.

3–24 LOAD PREPARATION PHASE (GROUND HANDLING PHASE)

3–24.1 SELECTION OF PARACHUTES

3–24.1.1 Extraction. The basic factor for selecting the extraction parachute size shall be the ratio of the extraction force the parachute develops at the aircraft release velocity to the weight of the rigged load to be airdropped. Loads to be extracted on the skate wheel and buffer board system shall be rigged with an extraction parachute so as to experience a ratio of extraction force to extraction weight which is between 0.5 and 1.0. If the aircraft is equipped with a dual-rail system, the ratio of extraction force to extracted weight for unit weights up to 25,000 pounds should be between 0.7 and 1.5 for the C-130 aircraft and between 0.8 and 1.5 for the C-141 aircraft. Firm criteria for extraction of unit weights exceeding 25,000 pounds have not yet been established; however, the maximum extraction ratio for structural design purposes may be taken as 1.5 times the extracted weight. Drag forces produced by standard extraction canopies for aircraft release velocities of 100 to 150 knots are shown in Table 3–7. It should be noted that these are based on nominal drag coefficients at instantaneous velocities and sea level conditions. Designers may be required to consider the effects of variation in drag coefficient, parachute size, extraction altitude, and influence of the

TABLE 3–7. DRAG FORCES PRODUCED BY STANDARD CARGO EXTRACTION CANOPIES [18]

AIRCRAFT RELEASE VELOCITY (KNOTS)	DRAG FORCE (lb)					
	RING-SLOT EXTRACTION PARACHUTES					
	15-FOOT REEFED TO: 10 FEET	12 FEET	15 FEET	22 FEET	28 FEET	35 FEET
100	1420	1850	3200	6,100	10,500	17,800
105	1550	2200	3400	7,000	12,200	18,600
110	1690	2430	3800	8,200	13,300	20,800
120	2010	2900	4500	9,700	15,500	24,600
130	2430	3380	5400.	11,400	17,500	28,600
140	2720	3950	6100	13,300	23,200	33,700
150	3140	4520	7050	15,200	26,200	38,600

wake behind different aircraft types. The extraction parachute size and type to be used for standard extraction systems are listed in Table 3—4.

3—24.1.2 Recovery. Recovery parachutes are selected to provide the desired rate of descent for the load being dropped. Design rates of descent for various recovery parachutes are discussed in par. 3—28.

3—24.2 DETERMINATION OF RECOVERY PARACHUTE RISER LENGTHS. When recovery parachutes are used in a cluster, the risers of each parachute must be lengthened so that the canopies will remain nearly vertical during descent. The risers are lengthened by using 20-foot cargo slings as riser extensions. The length of riser extension required for each G-11A and G-12D parachute used in a cluster is given in Table **3—8.**

One method that has been suggested as a rule of thumb in determining the lengths of parachute riser extensions in a cluster is to make a parachute group and maintain the same included angle in riser extension as in the riser (Fig. 3—81). The equation for determining the length is:

$$L_1 = L_2\left(\frac{r_2}{r_1} - 1\right) \qquad (3\text{—}1)$$

where

L_1 = length of parachute riser extension, ft

L_2 = length of parachute suspension lines plus riser length, ft

r_1 = radius of single inflated parachute, ft

r_2 = radius of inflated parachute cluster (plan form), ft

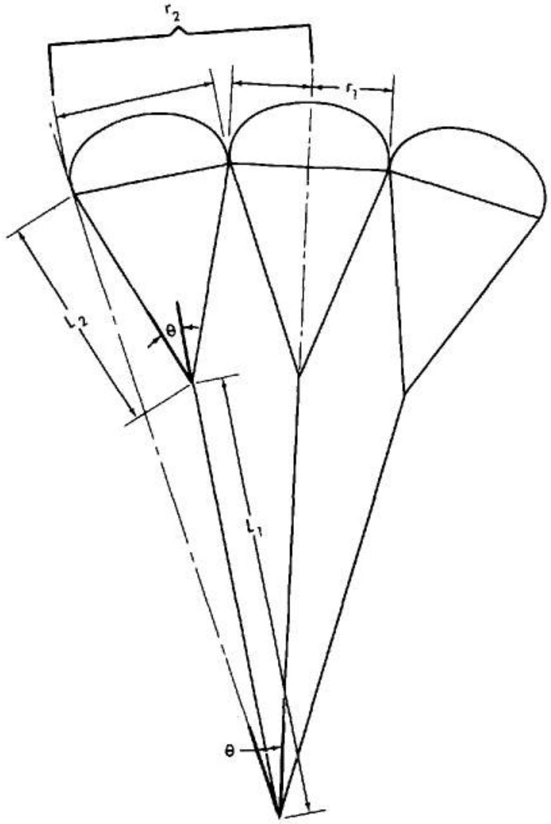


FIGURE 3–81. METHOD FOR DETERMINING PARACHUTE RISER EXTENSION LENGTHS

TABLE 3–8. LENGTH OF RISER EXTENSIONS REQUIRED FOR G-11A AND G-12D RECOVERY PARACHUTES IN CLUSTER

G-11A PARACHUTES		G-12D PARACHUTES	
NO. PER CLUSTER	RISER EXTENSION REQD (ft)	NO. PER CLUSTER	RISER EXTENSION REQD (ft)
2	20	2 0R 3	20
3	40		
4	60		
5	80		
6	80		
8	120		

The rule of thumb stated yields approximate riser extension lengths required. It has been found that when this rule of thumb is applied to large clusters of large parachutes, the resulting riser extension lengths are too long for practical use. Therefore, the lengths specified in Table **3–8** may be considered a compromise between maximum efficiency and practical configuration.

The general equation for the load on each riser is given by[18]:

$$F = \frac{F_{max} \cdot j}{N \cdot u \cdot o \cdot e \cdot f} \qquad (3\text{—}2)$$

where

F = load on each riser, lb

F_{max} = maximum parachute opening force, lb

j = safety factor = 1.5

N = number of individual webbings in riser

u = factor involving the strength loss at connection loop = 0.8

o = factor related to strength loss in material from water and water vapors absorption = **0.95** for nylon, 0.8 for silk, 0.5 for rayon

e = factor related to strength loss by abrasion = 1.00

f = factor related to strength loss by fatigue = 0.95

3—24.3 PLATFORM LOADING LIMITATIONS. The maximum load that can be placed on any standard platform is limited only by the strength of the aircraft floor as given in Chapter 4. The minimum rigged weight required on most standard platforms is based on square footage of the platforin. This weight is computed at 35 pounds per square foot for combat-expendable platforms and modular platforms. The minimum rigged weight for loads using the 6000-pound platform is 2800 pounds. The minimum rigged weights of loads placed on the 11-foot, 15-foot, and 22-foot standard B platforms are 2570, 3740, and 6420 pounds, respectively.

For planning purposes, the average range of values of the total rigged weight of material rigged for airdrop can be determined from Fig. 3—82. The values of the rigged weight derived from Fig. 3—82 may vary plus or minus 500 pounds from this average range for any particular item of material.

The minimum safe airdrop load weight for the CV-7A aircraft is shown in Fig. 3—83. This chart is applicable for aircraft speeds from 90 to **125** knots utilizing extraction parachutes ranging from **0.6** to **1.5** g's[37].

3—24.4 LOAD SILHOUETTE LIMITATIONS

3—24.4.1 C-119 Aircraft. The maximum height of the rigged load shall not exceed 82 inches when measured from the bottom of

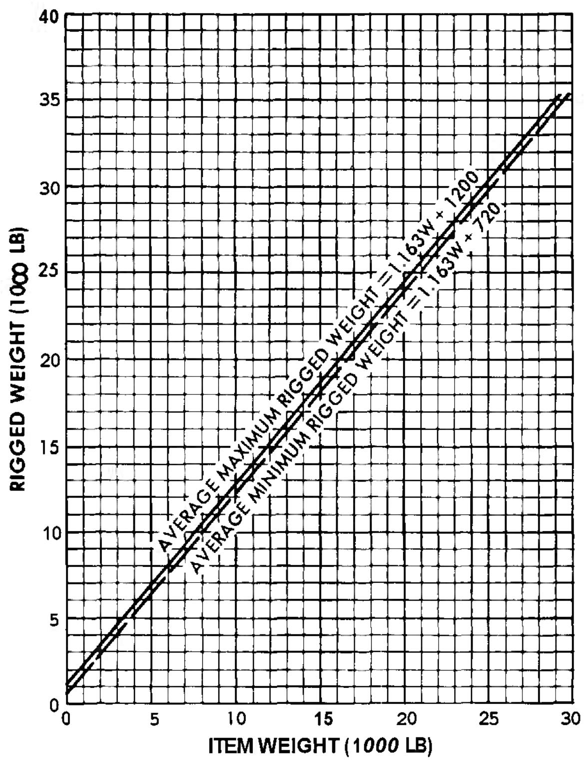


FIGURE 3-82. RIGGED WEIGHT VS GROSS WEIGHT USING MODULAR PLATFORM AND PAPER HONEYCOMB

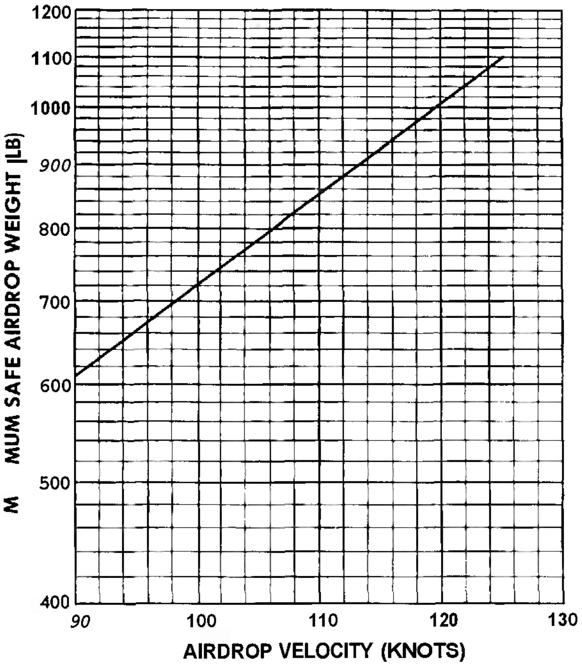


FIGURE 3-83. MINIMUM SAFE AIRDROP WEIGHT FOR CV-7A AIRCRAFT

the platform. However, when a portion of the load is greater than 23 inches laterally from the side of the platform, the height of that portion may be increased to 86-3/4 inches. The maximum width of the platform is 107 inches. The load must be at least 1 inch inboard from the edge of the platform laterally, which permits a maximum width of 105 inches.

3-24.4.2 C-130 Aircraft. No portion of equipment loaded on modular platforms shall extend outboard further than 1 inch past the restraint flange of the platform. A clearance of 1 inch shall be maintained inboard of the platform edge, regardless of the type of standard platform, if the load is rigged for. airdrop with the skate wheel system. Equipment that overhangs the ends of the platform shall not extend beyond an imaginary plane extending up from the lower edge of the platform at an angle of 30 degrees with the horizontal, and in no case will the overhang exceed 3 feet. The allowable height of the load, measured from the bottom of the platform. at any platform station, shall be determined by Fig. 3-84. The curves in Fig. 3-84 were derived by assuming the radius of gyration of the load is 6.33 feet, the aircraft is experiencing 1.4 positive g's, the height of the center of gravity of the load is 55 inches, and the velocity of the load at the ramp sill is 20 feet per second? Variance from any of these assumptions, especially the exit velocity, will invalidate. the curve to some degree. The height of the center of gravity of the load shall, not exceed the maximum values shown in Fig. 3-85.

3-24.4.3 C-141 Aircraft. The overall width of the load shall not exceed 110 inches. Figure 3-86 defines the load envelope for rigged, type II modular platforms up to 24 feet long and a maximum gross weight of 25,000 pounds. (Airdrop of loads weighing more than 25,000 pbunds may not be accomplished until flight test programs are completed.) Figure 3-86 shows the maximum heights to which airdrop platforms may be rigged, based on an extraction rate of 0.25 g. The heights allow a clearance of 6 inches above the XM-551 and 7.5 inches above other palletized loads. This clearance is the minimum permissible for adequate platform rotation as the load passes the teeter point at the aft edge of the ramp[39].

The maximum vertical cg of the load is 59 inches above the platform floor. The allowable cg tolerances of the 8-foot, 12-foot, 16-foot, 20-foot, and 24-foot type II modular platforms are shown in Fig. 3-87.

All platforms to be airdropped from the C-141 must be equipped with an extraction line 120 feet long. This may be a single line or two 60-foot lines connected with a type 4 connector link. The connector link must be padded with two thicknesses of 1-inch felt material covered with canvas material and tied or taped. Platforms requiring three or more cargo parachutes must have the parachutes restrained by two parachute restraint straps and rigged with two shear knives.

3-24.4.4 CV-2 Aircraft. Loads rigged on platforms or skidboards cannot exceed 61-1/4 inches in height when measured from the

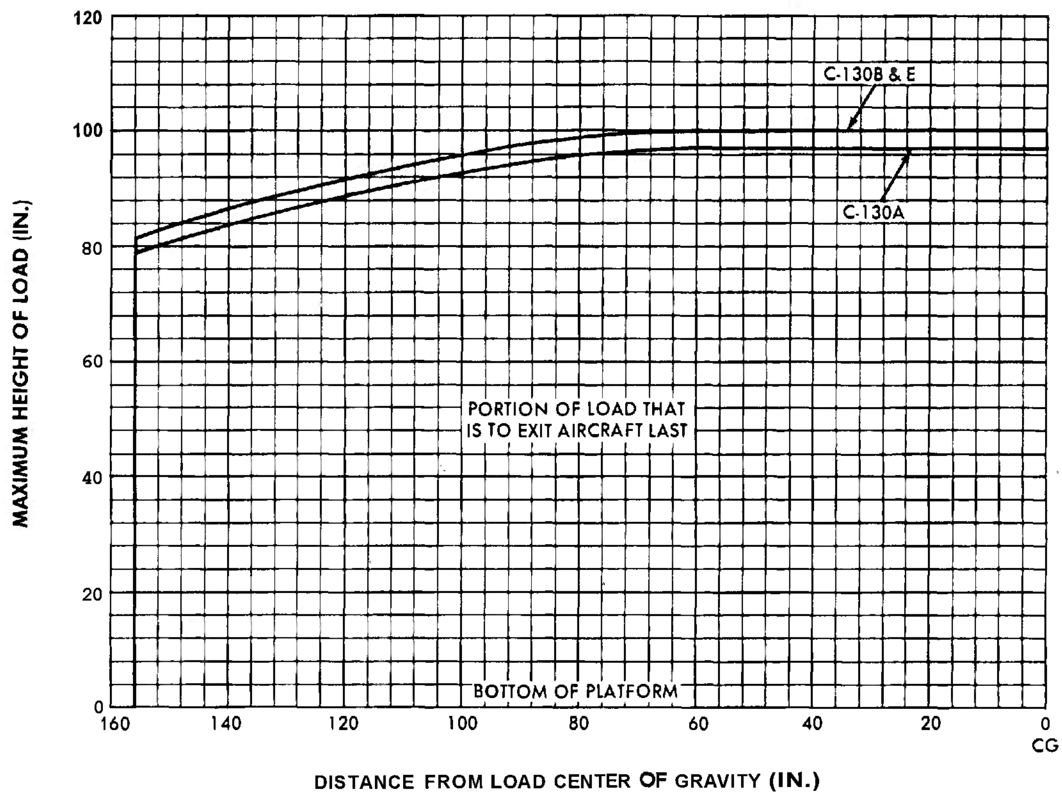


FIGURE 3-84. DIMENSION LIMITATION ENVELOPE FOR EXTRACTED LOADS FOR THE C-130 DUAL-RAIL KIT

bottom of the skid or platform, 70 inches in width, and 144 inches in length. In the event equipment on the load overhangs the platform or skid, a sufficient distance should be allowed between overhanging equipment and the adjoining load to prevent interference during extraction or gravity release and to allow access to tie-down fittings for load restraint.

3—24.4.5 CV-7A Aircraft. Figures **3—88** and **3-89** define the load envelope for rigged platforms up to a maximum of 216 inches long, in the weight range of 615 pounds minimum to 7500 pounds maximum. These curves may be used to determine the allowable rigged load heights for conducting standard heavy drop or low level extractions (LO LEX) as long as the following extraction criteria are met[37].

a. Aircraft airdrop speed range — 90 to 125 knots.

b. Aircraft cargo floor inclination — from 11 degrees nose-up to 6 degrees nose-down.

c. Maximum platform length — **18** feet.

d. Maximum forward overhang of load from platform — **0.30** x distance from load center of gravity to front of platform.

e. Maximum rear overhang of load from platform — **0.33** x distance from center of gravity of load to rear of platform.

f. Forward overhang shall not extend below a line extending upward from the front edge of platform at an angle of **35** degrees with the horizontal.

g. Center of gravity tolerance — maximum of 2 feet forward or aft of platform midpoint.

h. Platform loading — 15 pounds per square foot minimum to the maximum the aircraft will safely accept.

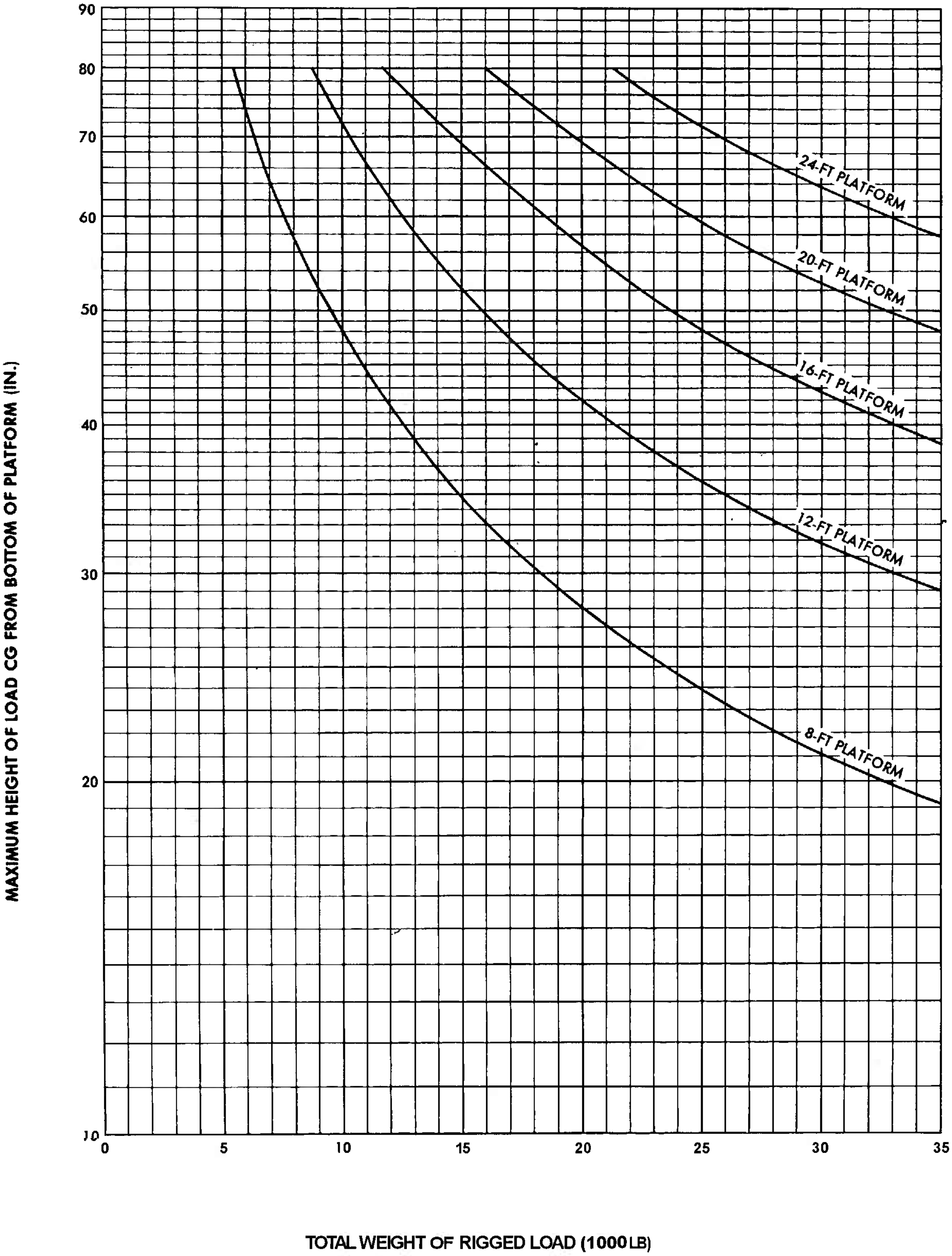


FIGURE 3-85. MAXIMUM CARGO CG HEIGHT FOR C-130 DUAL-RAIL KIT

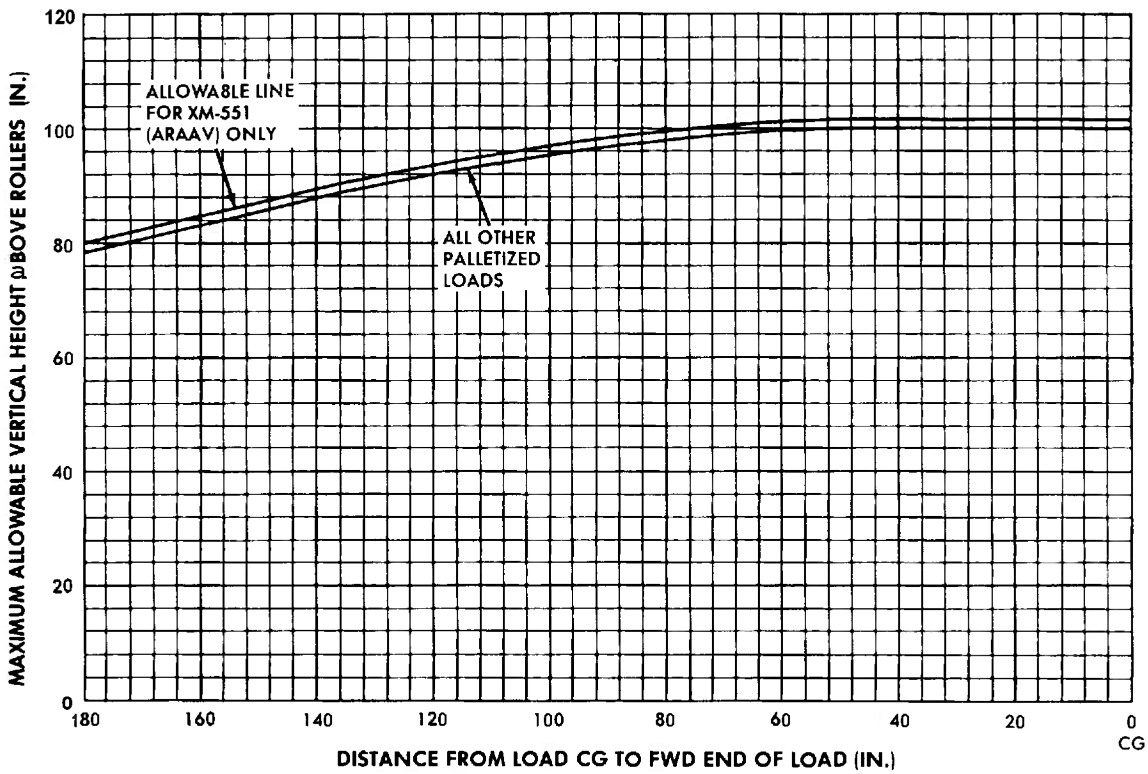


FIGURE 3–86. DIMENSION LIMITATION ENVELOPE FOR EXTRACTED LOADS FOR THE C-141 AIRCRAFT

i. Extraction rate range — *0.6* to **1.5** g's.

j. Load extraction velocity range — 10 feet per second to **45** feet per second.

k. The vertical location of the extraction point at approximately the vertical location of the center of gravity of the load (no platform extractions).

l. Minimum safe airdrop load weight is in accordance with Fig. 3–83.

3–24.5 RESTRAINT CRITERIA. Tiedown provisions are used to restrain the airdrop item to the platform or to the aircraft tiedown fittings, depending on the airdrop system used. The minimum number of tiedown provisions required on each side— based on forward restraint —is listed in Table 3–9. The values in Table 3–9 were computed based on the assumption that angles ϕ and β are 45-degree angles (Fig. 3–90). A more general equation for forward restraint is

$$nW = \sum_{i=1}^{N} R_i \cos\phi_i \cos\beta_i \qquad (3\text{–}3)$$

where

n = forward restraint factor (g-load factor)

W = load weight, lb

R = ultimate strength of a single tiedown, lb

i = particular strap providing a forward restraint component

N = total number of straps providing forward restraint component

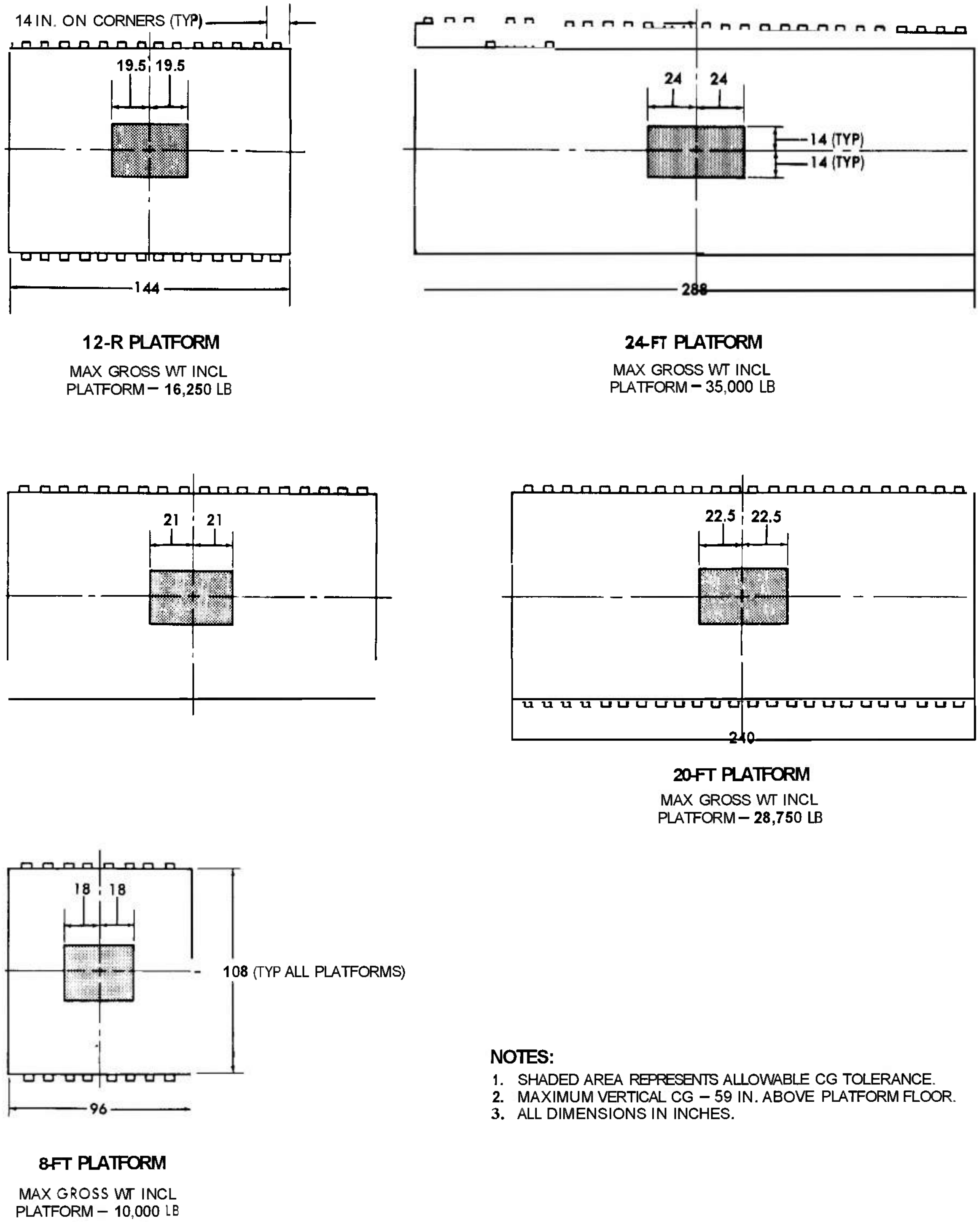


FIGURE 3-87. TYPE II MODULAR PLATFORM LOAD CG TOLERANCES FOR C-141 AIRCRAFT

INSTRUCTIONS FOR USE

1. PREPARE A XALE DRAWING OF THE MAXIMUM VERTICAL CONTOUR OF THE RIGGED LOAD (SCALE 1:20 HEIGHT, 1:40 LENGTH).
2. PLACE THE CG OF THE GROSS LOAD ON THE CG LINE OF THE ENVELOPE AND ALIGN THE BOTTOM OF THE PLATFORM WITH THE LOWER LINE OF THE ENVELOPE.
3. THE ENTIRE LOAD CONTOUR MUST FALL WITHIN THE ENVELOPE. (THE ABOVE STEPS MAY BE ACCOMPLISHED IN FULL SCALE BY READING THE HEIGHTS FOR VARIOUS STATIONS OF THE ENVELOPE AND COMPARING THEM WITH HEIGHT MEASUREMENTS AT CORRESPONDING STATIONS OF THE ACTUAL RIGGED LOAD.)
4. MAXIMUM PLATFORM LENGTH SHALL NOT EXCEED 216 IN.
5. THE HEIGHT OF THE RIGGED LOAD SHALL NOT EXCEED 68.8 IN.

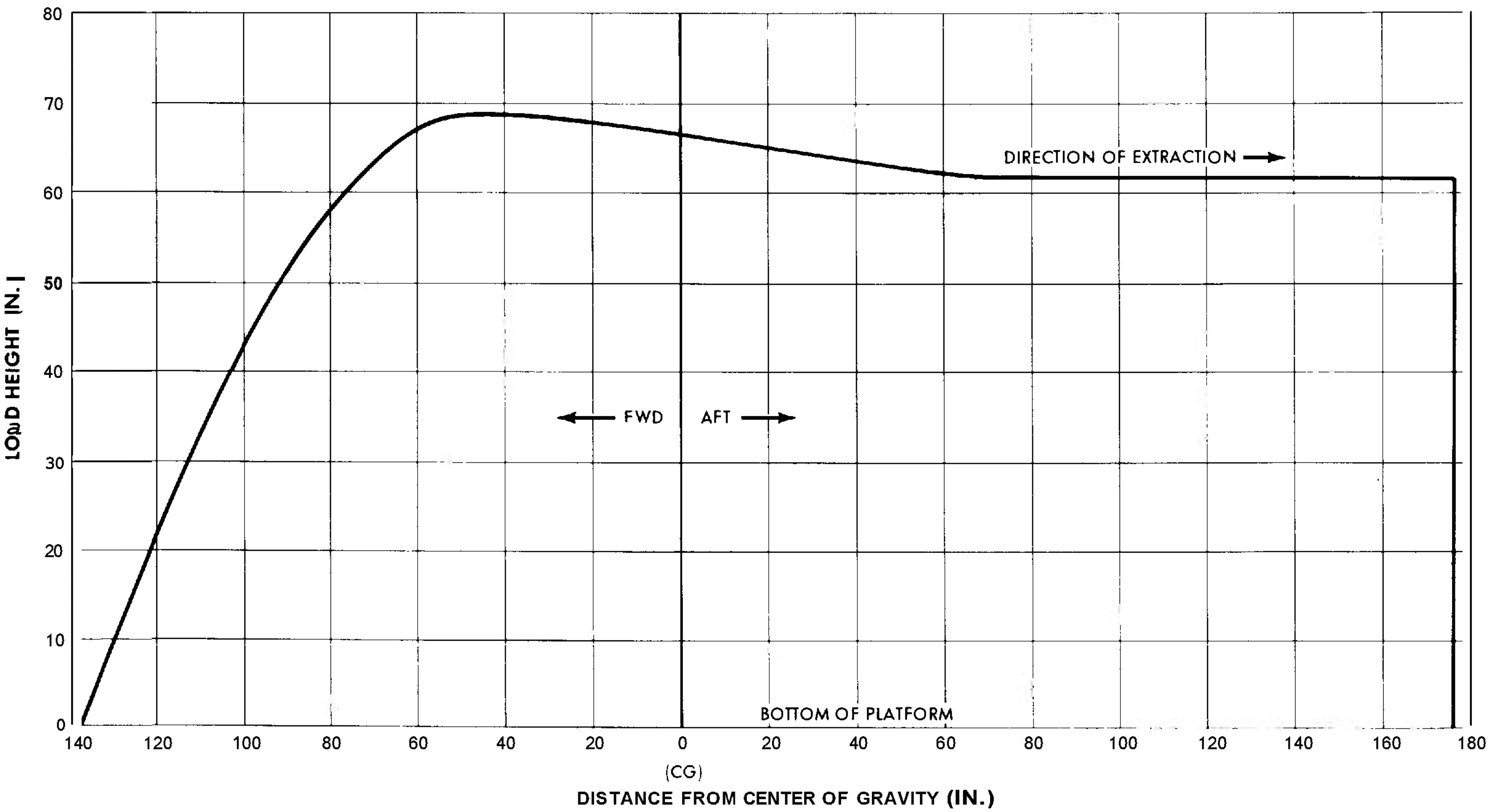


FIGURE 3-88. DIMENSION LIMITATION ENVELOPE FOR EXTRACTED LOADS FOR THE CV-7A AIRCRAFT (RAMP HORIZONTAL)

INSTRUCTIONS FOR USE

1. PREPARE A SCALE DRAWING OF THE MAXIMUM VERTICAL CONTOUR OF THE RIGGED LOAD (SCALE 1:20 HEIGHT, 1:40 LENGTH).
2. PLACE THE CG OF THE GROSS LOAD ON THE CG LINE OF THE ENVELOPE AND ALIGN THE BOTTOM OF THE PLATFORM WITH THE LOWER LINE OF THE ENVELOPE.
3. THE ENTIRE LOAD CONTOUR MUST FALL WITHIN THE ENVELOPE. (THE ABOVE STEPS MAY BE ACCOMPLISHED IN FULL SCALE BY READING THE HEIGHTS FOR VARIOUS STATIONS OF THE ENVELOPE AND COMPARING THEM WITH HEIGHT MEASUREMENTS AT CORRESPONDING STATIONS OF THE ACTUAL RIGGED LOAD.)
4. MAXIMUM PLATFORM LENGTH SHALL NOT EXCEED 216 IN.
5. THE HEIGHT OF THE RIGGED LOAD SHALL NOT EXCEED 68.8 IN.

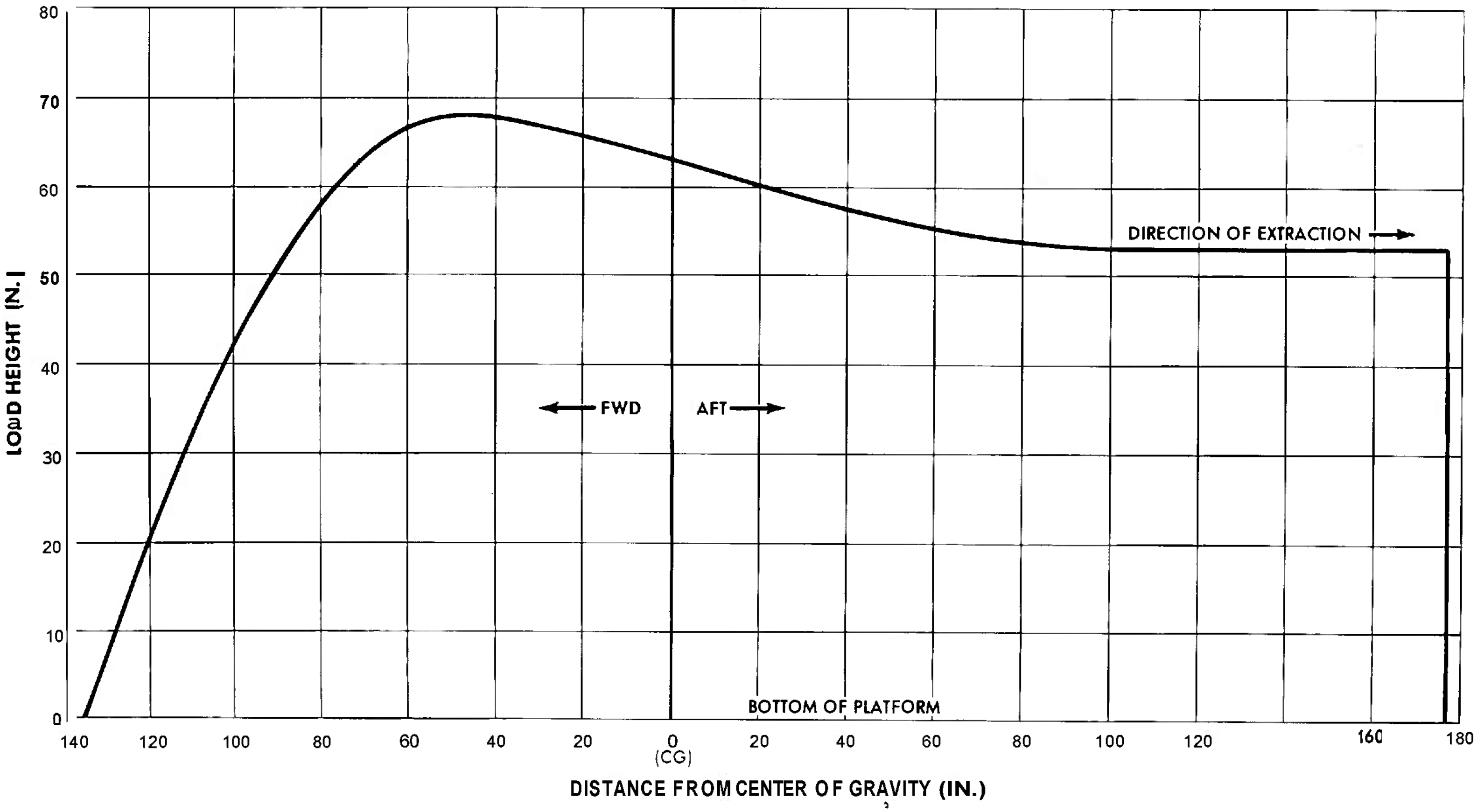


FIGURE 3–89. DIMENSION LIMITATION ENVELOPE FOR EXTRACTED LOADS FOR THE CV-7A AIRCRAFT (RAMP 15 DEGREES BELOW HORIZONTAL)

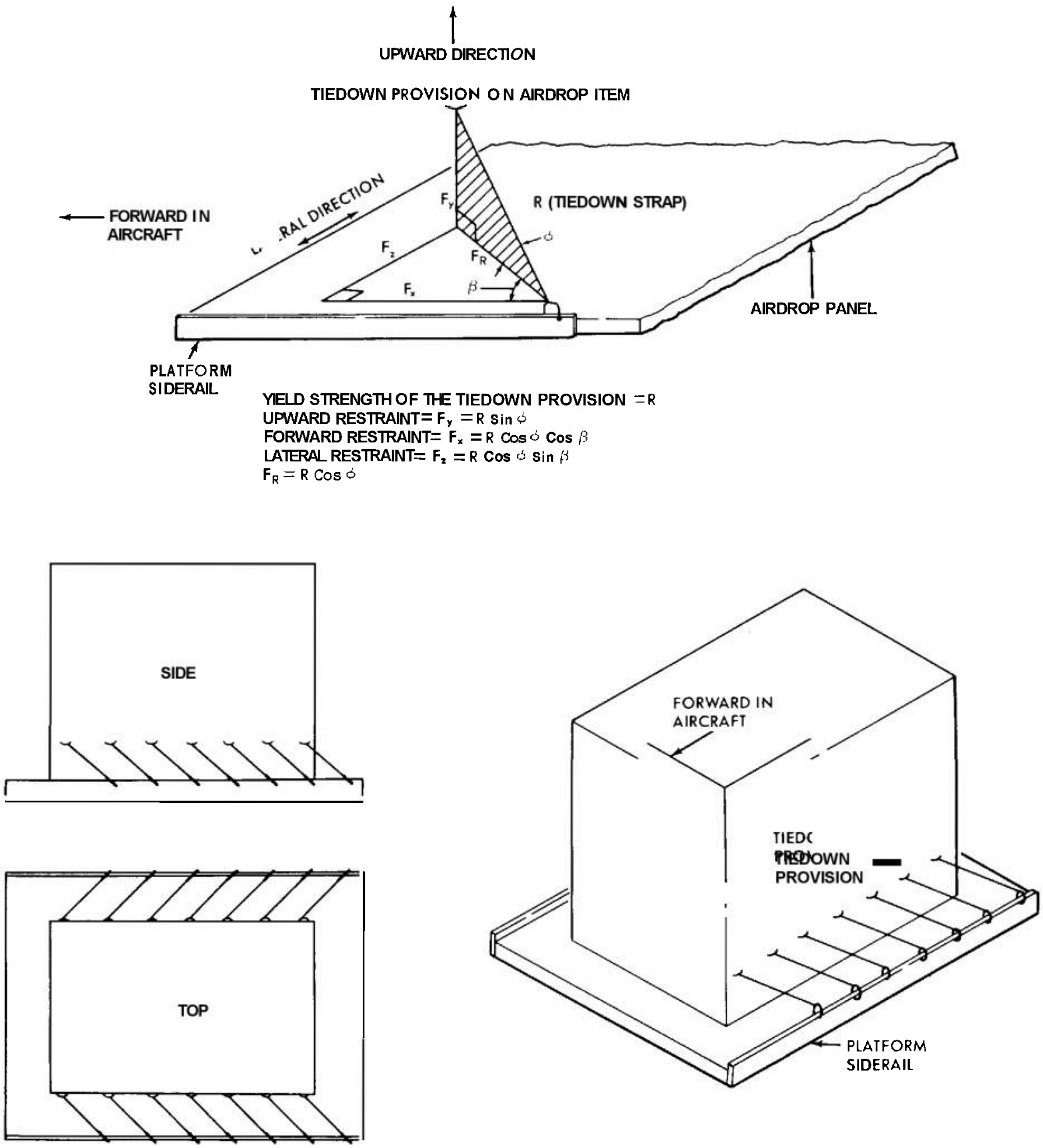


FIGURE 3-90. TIEDOWN SYSTEM GEOMETRY

AIRDROP WEIGHT (lb)	NUMBER OF TIEDOWNS REQUIRED PER SIDE	LIMIT OF LOAD CAPACITY OF TIEDOWN PROVISIONS (lb)
1,120 – 2,200	3	5,000
2,201 – 3,275	4	5,000
3,276 – 4,350	5	5,000
4,351 – 4,999	6	5,000
5,000 – 5,430	3	10,000
5,431 – 7,580	4	10,000
5,581 – 9,740	5	10,000
9,741 – 11,890	6	10,000
11,891 – 14,050	7	10,000
14,051 – 14,999	8	10,000
15,000 – 16,200	4	20,000
16,201 – 20,510	5	20,000
20,511 – 24,820	6	20,000
24,821 – 29,130	7	20,000
29,131 – 33,440	8	20,000

The combined resultant restraint of the tiedown system shall be of sufficient strength to restrain the following minimum forces:

	Forward	Aft	Up
For use with skate wheel and buffer board system	2.0 g's	2.0 g's	2.0 g's
For use with dual-rail system	4.0 g's	1.5 g's	2.0 g's

If the airdrop item width exceeds 60 inches, additional tiedown provisions may be required on the front and rear of the item for proper lateral restraint. This restraint will be equal to a minimum of 2.0 g's for items dropped with skate wheel and buffer board system or 1.5 g's for items dropped with dual-rail system. Where practical, the spacing of tiedown provisions should be approximately equal and should use corresponding points of attachment on opposite sides of the item. Figure 3–91 illustrates a typical rigged load.

3–25 AIRCRAFT LOADING PHASE

3–25.1 DESCRIPTION OF LOADING OPERATIONS. Loading of rigged loads into the aircraft

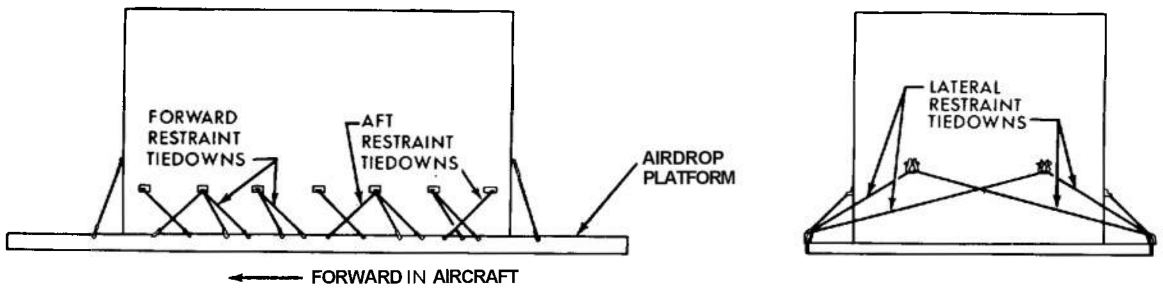


FIGURE 3–91. TYPICAL RIGGED LOAD SHOWING TIEDOWNS

can be accomplished in many ways, depending upon the availability of hoisting equipment, transporting vehicles, the type of rigged load to be transported, and the type of aircraft to be used as the final cargo carrier. The rigging unit must determine the type of aircraft to be used as the cargo carrier and then so prepare the rigged load for transport that the offloading procedures are compatible with the cargo loading system of the aircraft.

Rigged loads can be hoisted aboard the transporting vehicle by means of hoisting equipment, such as the 5-ton wrecker, the 10,000- or 15,000-pound capacity warehouse crane, or the 15,000-pound capacity forklift truck. Any standard military truck or semitrailer with sufficient cargo space can be modified for use to transport a rigged load from the loading area to the cargo aircraft; however, not all military trucks are compatible with the cargo loading system of all cargo aircraft, and the rigged load may require transfer at the aircraft site prior to offloading the rigged load into the cargo aircraft. Procedures for preparing typical transporting vehicles, positioning and securing rigged load on the transporting vehicle, and preparing for offloading into the aircraft are described in TM 10-500[7].

3—25.2 RIGGING AIRDROP LOAD FOR AUTOMATIC RELEASE BY EXTRACTION SYSTEM. The extraction parachute is placed on the rigged load to be installed after the rigged load is positioned in the aircraft. The size and type of the extraction parachute is determined as outlined in par. 3—24.1.1 and will be specified in the rigging procedures for the load (TM 10-500-series manuals).

During a fixed-pin platform airdrop operation utilizing the dual-rail system (par. 3—1 1.1.1), an extraction parachute cable release mechanism mounted on the aft end of the conveyor frame assembly provides for the automatic release of the cable attached to the extraction parachute (Fig. 3—23) and also locks the parachute release cable assembly in the full release position when the deployed extraction parachute exerts sufficient pull on the cable.

3—25.2.1 Breakcord Strength Requirements (Fixed-pin Platforms). Platform breakcord ties are installed on the forward corners of fixed-pin modular platforms and secured to the nearest rollers forward of the platform. The breakcord restrains the load in the aircraft until the extraction parachute has enough force to break the breakcord. The purpose of the breakcord is to prevent movement of the platform if it is accidentally unlocked, and, because of malfunction, extraction force is not applied. It also prevents aft movement of the platform until the extraction parachute has fully inflated. The breakcords to be used with various platform rigged weights are as follows:

LOAD WEIGHT	PLATFORM BREAKCORDS
2500-3700 lb	1 loop, 550-lb cord on forward left corner only.
3701 - 8000 lb	1 loop, 550-lb cord on forward left and right corners.
8001 - 17,000 lb	1 loop, 1000-lb tubular nylon cord on forward left and right corners.
17,001 - 25,000 lb	2 loops, 1000-lb tubular nylon cord on forward left and right corners.

3—25.2.2 Variable Aft Restraint Settings (Indented Platforms). For dual-rail systems employing the indent/detent system, aft restraint is provided by latches mounted on the right-hand rails. The latch detents are spring-loaded and mate with the platform indents. The latches are preset to provide the proper amount of aft restraint based on supplying 0.5g at a given rigged platform weight. The number of latches to be preset and instructions for setting the latches for various platform lengths versus rigged weights are given in the applicable cargo aircraft -9 Technical Manual. The detents **will** disengage and remain disengaged when the preset force is overcome by the extraction parachute force.

3—25.3 RIGGING FOR SEQUENTIAL AIRDROP. In sequential platform airdrops, the extraction parachute for the second and each succeeding platform is attached to the platform which is to precede it out of the aircraft. The extraction parachute is then deployed by the extracted platform. Thus, sequential extraction and recovery parachute deployment are accomplished until the last platform has cleared the aircraft. The extraction parachutes should be rigged as low as possible on the preceding platform centerline, preferably on the platform itself.

3—26 EXTRACTION PHASE

3—26.1 CHARACTERISTICS OF EXTRACTION. The extraction phase of an airdrop includes: (1) release, extension, and inflation of the extraction parachutes to actuate the release mechanism or overcome the breaking strength of the platform restraint cords and initiate motion of the load; (2) movement of the load from the initial position to the last point where rotational restraint is maintained or the point where tipoff can begin; and (3) tipping off of the load to the point of separation from the aircraft..

3—26.2 ANALYSIS OF EXTRACTION. For analytical considerations, the extraction process may be broken down into the following three stages: (1) release and deployment of the extraction parachute; (2) release of the cargo and extraction through the aircraft cargo compartment; and (3) tipping off of the cargo. The release and deployment phase is usually not critical and it is assumed that extraction begins when the extraction parachute is extended and has begun to inflate. (Release and deployment times are, of course, important from an operational standpoint since they must be considered in computing the release point in turn of range from the intended impact point). A method for calculating deployment times for standard extraction parachutes may be found in Reference **40.**

A number of simplifying assumptions are usually made in most analyses of extraction. These include the following:

a. **All** motion occurs in a vertical plane through the path of the aircraft.

b. The aircraft is flying a straight and level course, at constant velocity, and the aircraft floor is horizontal.

c. The direction of the extraction force is parallel to the aircraft floor, up to the point of tipoff.

d. The platform and cargo represent a single rigid body.

e. Textile components between the parachute and cargo are inextensible (except for calculations of snatch force).

f. Friction between the platform and the aircraft is negligible.

3—26.2.1 Extraction Parachute Inflation. It has been found that the following empirical relationship is reasonably accurate when applied to extracting parachutes of standard size and configuration.

$$t_f = \frac{8D_o}{V^{.9}}\,\sigma \qquad (3\text{—}4)$$

where

t_f = time to full inflation, sec

D_o = diameter of parachute (based on constructed area), ft

V = parachute velocity, assumed constant for the interval $t = 0$ to $t = t_f$ and equal to the aircraft velocity at release, ft, sec

$\sigma = \frac{\rho}{\rho_o}$ = ratio of density at altitude to density at sea level.

Another assumption, which is often made, is that the area growth of the extraction parachute is linear from $t = 0$ to $t = t_f$, or

$$A = A_o + \frac{A_f - A_o}{t_f} t \qquad (3\text{—}5)$$

where

A_o = parachute area at $t = 0$, ft^2

A_f = parachute area at $t = t_f$ (i.e., $\frac{\pi D_o^2}{4}$), ft^2

If it is further assumed that the parachute area = 0 at $t = 0$, then, combining Eqs. 3-4 and 3—5 yields

$$A = A_f \frac{V^{.9} t\sigma}{8D_o} \qquad (3\text{—}6)$$

Combining this result with the standard drag equation

$$F_D = \frac{\rho}{2} C_D A V^2 \qquad (3\text{—}7)$$

yields a linear variation of drag force with respect to time

$$F_D = \frac{\rho_o C_D A_f V^{2.9} t\sigma^2}{16 D_o} \qquad (3\text{—}8)$$

where

F_D = drag force, lb

C_D = parachute drag coefficient (C_D = 0.55 for ring-slot extraction parachutes)

t = time, sec.

This equation is valid until the cargo is released and is free to move. For systems employing the dual-rail systems, the cargo is released when the drag force exceeds some predetermined restraint level, usually 0.5 times the cargo weight to be extracted.

S26.2.2 Release of load. If the parachute is still inflating at cargo release, and the parachute force is horizontal then:

$$m\dot{V} = -\frac{C_D \rho}{2} V^2 \left(A_o + \frac{A_f - A_o}{t_f} t\right) \qquad (3\text{—}9)$$

where

A = area of parachute at cargo release, ft^2

t = 0 at the beginning of this stage.

This equation is solved for velocity and displacement in Reference 9. It should be noted that the equation must be modified as follows when the parachute reaches full inflation (usually before extraction has been completed).

$$m\dot{V} = C_D \frac{\rho}{2} A_f V^2 = -cV^2 \qquad (3\text{—}10)$$

The solution of this equation is

$$V = \frac{V_o}{1 + \frac{c}{m} V_o t} \qquad (3\text{—}11)$$

where

V_o = initial velocity at $t = 0$ for the interval for which the equation is written, ft/sec.

c = $-C_D \frac{\rho}{2} A_f$

m = mass of the extracted cargo, slug.

Since $V = \dot{x}$,

Eq. 3—11 may be integrated again and

$$x = \frac{m}{c} \ln\left(1 + \frac{c}{m} V_o t\right) \qquad (3\text{—}12)$$

where

x = horizontal distance from axes fixed in space at time $t = 0$ in the interval being investigated, ft.

For preliminary analyses, it is often assumed that the parachute is fully inflated at cargo release. In this case, Eqs. 3—11 and 3—12 are valid for the entire extraction period. The initial velocity V_o will then be equal to the aircraft velocity at release,

(t = 0). The distance traveled by the aircraft is $V_o t$ and therefore, the distance Δx traveled by the cargo with respect to the aircraft is:

$$\Delta x = V_o t - \frac{m}{c} \ln\left(1 + \frac{c}{m} V_o t\right) \qquad (3\text{—}13)$$

The velocity of the cargo with respect to the aircraft is given by

$$\Delta V = V_o - \frac{V_o}{1 + \frac{c}{m} V_o t} \qquad (3\text{—}14)$$

Typical time histories based on the above equations are plotted in Fig. 3—92 for a load weight of **4060** pounds and an aircraft speed of 100 knots for an extraction ratio of 1.5g and for a load weight of 8700 pounds at 100 knots for an extraction ratio of 0.7g using a 22-foot ring-slot parachute. If the extraction distance is known for cargo in a particular aircraft, the exit time and exit velocity may be determined from curves of this type.

3—26.2.3 Tipping-off. The angular velocity of the load is found by integrating the equation for change in angular momentum about the origin at the edge of the exit.

$$m \frac{d}{dt} \left[(k^2 + x^2 + d_1^2)\dot{\phi} - \dot{x}\, d_1 \right] =$$

$$- F d_2 - F\left(\frac{L}{2} + x\right)\phi + mgx \qquad (3\text{—}15)$$

where

- m = mass of platform, slug
- k = radius of gyration of platform and load, ft
- x = horizontal coordinate in space, ft
- $\dot{x}$ = horizontal velocity component, ft/sec
- d_1 = distance of bottom of platform below cg of platform and load, ft
- ϕ = angle between platform and horizontal, rad
- $\dot{\phi}$ = angular velocity of platform, rad/sec
- F = parachute force, lb
- d_2 = distance of point of parachute attachment below cg of platform and load, ft
- L = length of platform, ft
- g = acceleration due to gravity, ft/sec^2.

A precise evaluation of the angular velocity is presented in Reference **9.** The vertical velocity of the cg is given by

$$V_v = x\dot{\phi} \qquad (3\text{—}16)$$

and the vertical displacement is given by

$$y = x \tan\phi \; . \qquad (3\text{—}17)$$

3—27 FORCE TRANSFER AND RECOVERY PARACHUTE DEPLOYMENT AND OPENING PHASE

3—27.1 FACTORS AFFECTING TUMBLE. During the extraction of an item of cargo from an aircraft, several variables are prominent in determining the amount of tumbling that will develop. One of the most important is the rate of extraction. From **Fig. 3—93,** it can be seen that the tendency for the cargo to rotate about the edge of the aircraft ramp is a function of the period of time the cg is past the ramp edge while part of the cargo is in contact with the ramp. The angular acceleration thus imposed is given by

$$\ddot{\phi} = \frac{M}{I} \qquad (3\text{—}18)$$

where

- $\ddot{\phi}$ = angular acceleration, rad/sec^2
- M = moment about cargo cg, in.-lb
- I = mass moment **of** inertia **of cargo** about cg, lb-in^2.

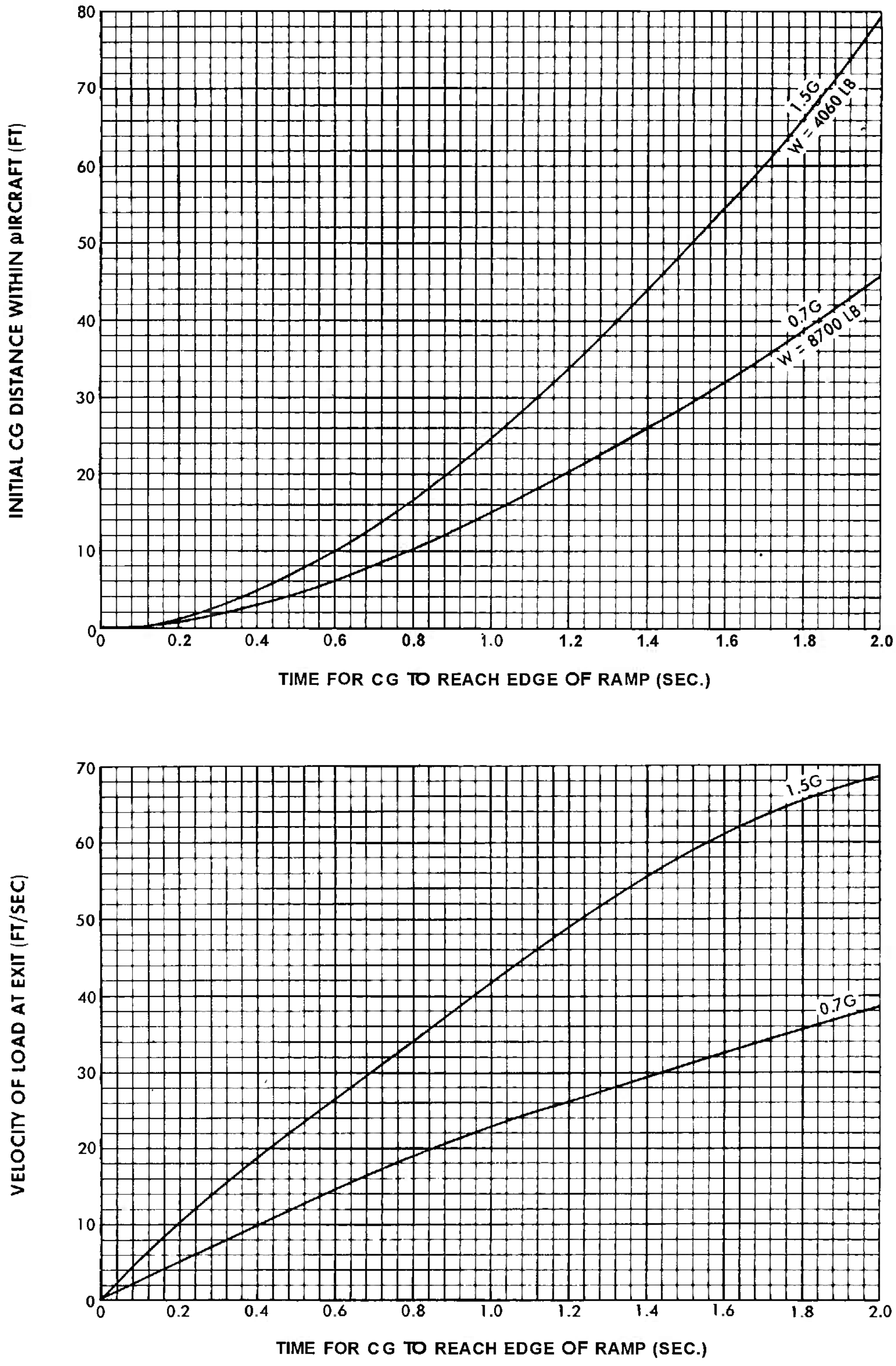


FIGURE 3-92. TYPICAL TIME HISTORIES OF LOAD MOTION DURING EXTRACTION

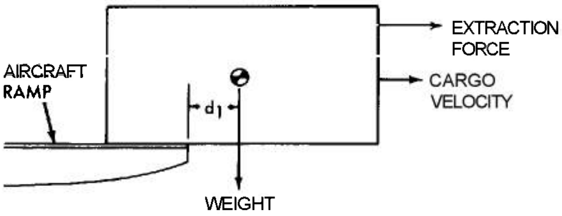


FIGURE 3-93. SKETCH OF CARGO LOAD ON EDGE OF RAMP

At beginning of tipoff, where the angle of tilt is small,

$$M = Wd_1 \tag{3-19}$$

where

W = cargo weight, lb

d_1 = distance of cargo cg past ramp, in.

Since $d_1 = Vt$, where t is time during which the cg is past the ramp, Eq. 3-18 can be written as

$$\ddot{\phi} = \frac{WVt}{I} \tag{3-20}$$

It thus becomes apparent that the angular acceleration imposed on the cargo is a function of its velocity and length, since length will determine the time to clear the ramp at a given velocity.

Another consideration at this point is the addition or subtraction to the tipoff moment of the moment due to the extraction force. This moment is set by the extraction parachute attachment points and the extraction force. A coupling of these two moments could lead to large angular accelerations. It should also be noted that the timing of extraction force transfer will affect tumble since the moment on the cargo is thereby removed. Platform position with respect to the aircraft ramp edge must, therefore, be considered in the analysis of the effect of force transfer on platform tumble. Aerodynamic moments on the platform may also be significant, especially for lightly loaded platforms. The maximum angle of tumble will be a function of the rotational velocities and accelerations acquired by the cargo between the time the platform reaches the aircraft ramp and the time at which the recovery parachutes begin to retard the cargo.

3-27.2 EFFECTS OF TUMBLE. Figure 3-94 depicts the tumble which platform rigged airdrop loads experience during deployment of the parachute system and provides the basis of the design criteria for the suspension provision.

3-27.3 ANALYSIS OF DEPLOYMENT AND LOAD TRAJECTORY

3-27.3.1 Basic Technique. A semigraphical analysis has been developed to predict the motion of the cargo and parachutes, during the airdrop[32]. This method is reasonably accurate and has the advantage that access

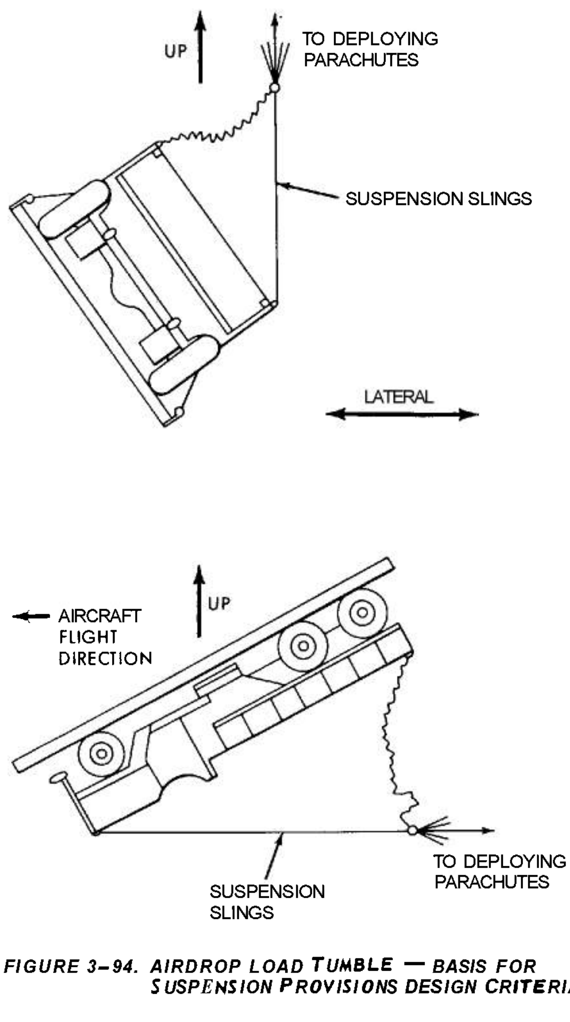


FIGURE 3-94. AIRDROP LOAD TUMBLE — BASIS FOR SUSPENSION PROVISIONS DESIGN CRITERIA

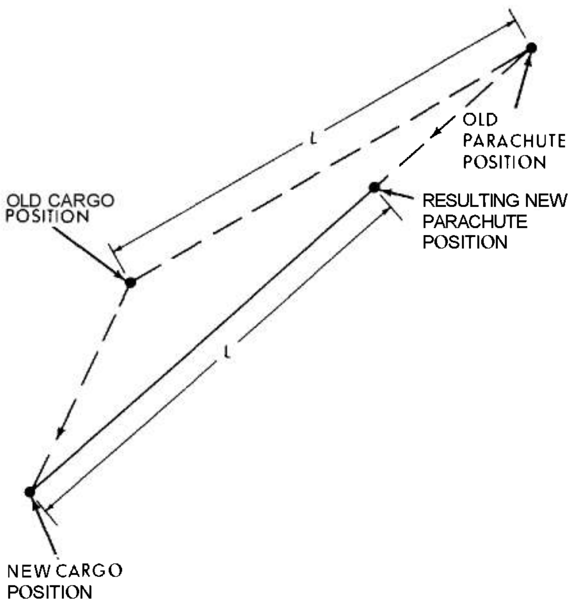


FIGURE 3–95. MOTION OF PARACHUTE WITH RESPECT TO CARGO

to a computer is unnecessary. The approach consists of determining parachute positions and velocities under graphical constraint and analytically determining cargo positions and velocities based upon graphical resolution of forces. Figures **3–95** and **3–96** illustrate the force acting on the cargo and the graphical method employed to determine the position after some time increment Δt. The resultant force F_R acting on the cargo is determined by vectorially adding F_w (cargo weight) and F_D (parachute drag force). This resultant is resolved in horizontal and vertical force components F_x and F_y for use in computing the components of acceleration (and or deceleration) acting on the cargo:

$$a_x = \frac{F_x}{m_b} \tag{3–21}$$

$$a_y = \frac{F_y}{m_b} \tag{3–22}$$

where

a_x = cargo acceleration in horizontal direction, ft/sec^2

a_y = cargo acceleration in vertical direction, ft/sec^2

F_x = cargo force component in horizontal direction, lb

F_y = cargo force component in vertical direction, lb

m_b = mass of cargo, slug.

*3–27.3.1.1 **Cargo Trajectory.*** The change in horizontal and vertical velocity that results due to the action of these components of acceleration over a time increment Δt are computed from:

$$\Delta V_x = a_x \Delta t \tag{3–23}$$

$$\Delta V_y = a_y \Delta t \tag{3–24}$$

where

ΔV_x = change in cargo horizontal velocity, ft/sec

ΔV_y = change in cargo vertical velocity, ft/sec

Δt = time increment, sec.

The average velocities over the time increment are given by

$$\bar{V}_x = V_x + \frac{\Delta V_x}{2} \tag{3–25}$$

$$\bar{V}_y = V_y + \frac{\Delta V_y}{2} \tag{3–26}$$

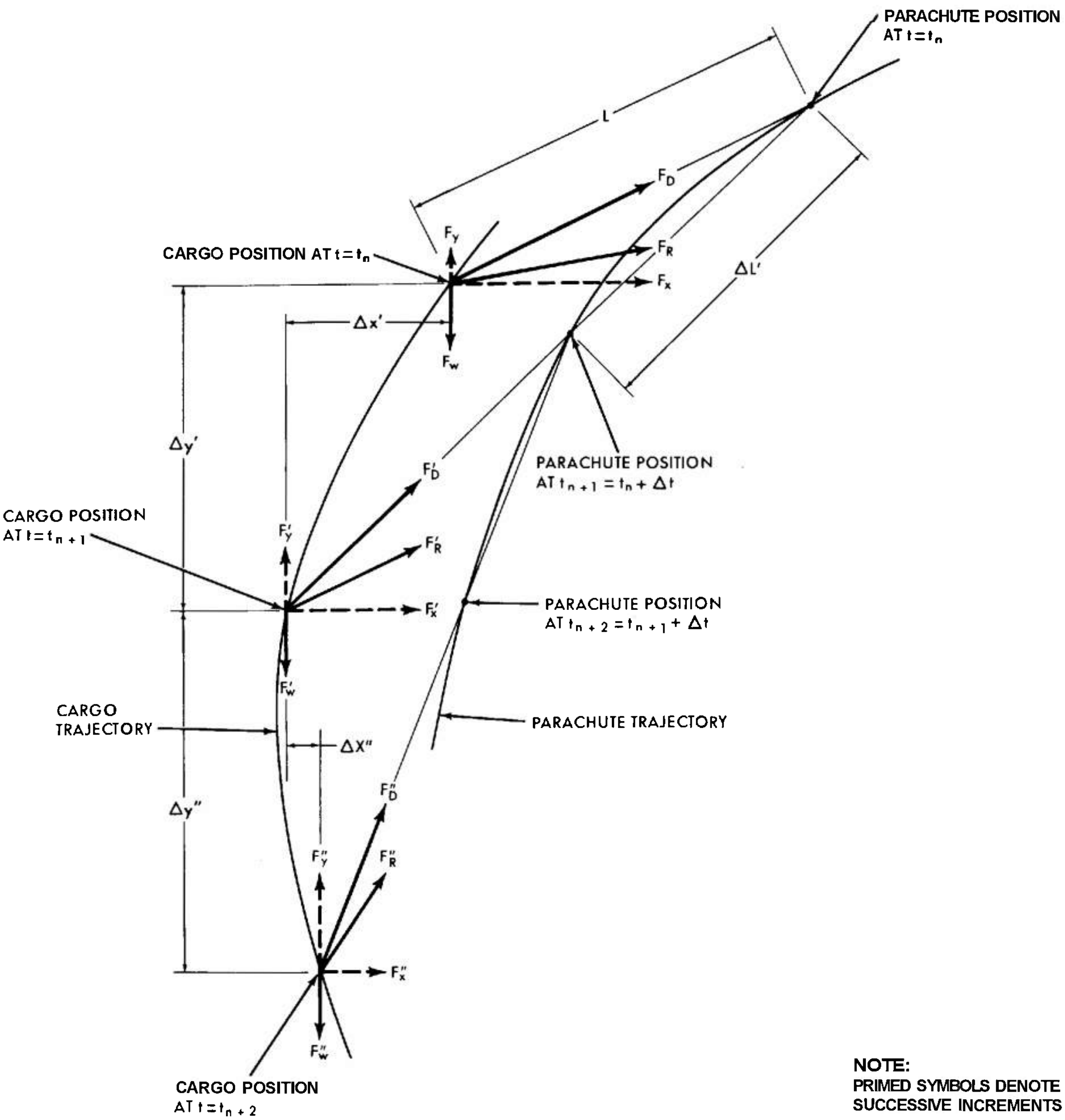
where

$\bar{V}_x$ = average cargo velocity in horizontal direction, ft/sec

$\bar{V}_y$ = average cargo velocity in vertical direction, ft/sec

V_x = velocity component of cargo in horizontal direction at beginning of time increment, ft/sec

V_y = velocity component of cargo in vertical direction at beginning of time increment, ft/sec.



NOTE:
PRIMED SYMBOLS DENOTE SUCCESSIVE INCREMENTS

FIGURE 3-96. GRAPHICAL METHOD OF PROGRESSING FROM POINT TO POINT

Finally, the new cargo position resulting after Δt seconds can be determined from:

$$\Delta x = \bar{V}_x \Delta t \qquad (3\text{-}27)$$

$$\Delta y = \bar{V}_y \Delta t \qquad (3\text{-}28)$$

where

Δx = incremental displacement of cargo in horizontal direction, ft

Δy = incremental displacement of cargo in vertical direction, ft.

By continually summing Δx and Δy, the trajectory of the cargo may be plotted.

***3—27.3.1.2* Parachute Drag Force.** The direction of the parachute force F_D must be known at the beginning of each time increment so that the vectorial addition of F_D and F_w may be carried out. Therefore, it is assumed that during time increment **At**, the parachute is dragged to a new position as indicated in Fig. **3—95.** This assumption neglects parachute motion due to its own weight; however, since this weight is very small in comparison with the parachute drag force, the assumption is quite valid and simplifies the analysis considerably.

The magnitude of the parachute drag force F_D may be computed once the new cargo position has been determined. The average velocity of the parachute during the time increment **At** is

$$\bar{V}_P = \frac{AL}{At} \tag{3—29}$$

where

$\bar{V}_P$ = average velocity of parachute during time increment **At**, ft/sec

AL = linear distance traveled by parachute during time increment **At**, ft.

The magnitude of the parachute drag force is then

$$F_D = \frac{\rho}{2} \bar{V}_P^2 C_D S_o \quad \text{(multiplied by the parachute drag area ratio, if applicable)} \tag{3—30}$$

where

F_D = total drag force of parachute, lb

ρ = density of air, slug/ft^3

C_D = parachute drag coefficient

$S_o = \frac{\pi D_o^2}{4}$ projected area of parachute, ft^2

D_o = nominal diameter of parachute, ft.

If the parachute utilized is reefed, the drag area ratio (par. **3—15.1.6**) must be used as a multiplying factor in **Eq. 3—30.**

***3—27.3.1.3* System Trajectory.** The linear distance traveled by the parachute ΔL is obtained graphically at the end of each time interval, by taking measurements from a scale drawing (as in Fig. **3—95**) which describes the position of the cargo with respect to the position of the parachutes for each time increment **At.** Thus, starting with known positions of the cargo and parachutes at the beginning of the analysis, the changes in position of the cargo are calculated, and the changes of parachute position are graphically constructed, for each succeeding time increment. If this is done continuously and step-by-step for each time increment, a trajectory curve for both the cargo cg and the parachute *cg* will be obtained. For heavy cargo systems, a time increment of **0.1** second should be used together with a one-eighth (or larger) scale graphical construction to obtain the most accurate results.

3—27.3.2 Parameters. The above discussion describes the basic technique for proceeding with the semigraphical trajectory analysis. In applying this technique to particular airdrop systems, however, the initial geometric relationships which are established during parachute deployment must be known or obtained. Additionally, the transient conditions associated with parachute opening must be accounted for.

***3—27.3.2.1* Deployment.** Since there is no change in altitude during extraction, it is reasonable to start the trajectory analysis with $t = 0$ at the time of cargo exit. The horizontal velocity of the cargo at this time is obtained as described in par. *3—26.* If the extraction force transfer occurs reasonably close to cargo exit, as it does in standard systems, the cargo then may be assumed to follow a ballistic trajectory until the parachute deploys and begins to open. Parachute deployment time may be assumed based on experimental data or may be calculated by the methods of Reference 18. At the end of the deployment time, the cargo will have acquired a displacement and velocity due to its ballistic trajectory and the cargo position may be located on the drawing. It may now be assumed that the fully deployed parachute is aligned with the cargo velocity vector. (This is a simplifying assumption which is reasonable for standard airdrop systems, since the force developed by the parachute up to this point is too low to affect the trajectory appreciably.) The velocity of the parachute at the end of deployment is assumed to be equal in magnitude to the cargo velocity vector and the relative position of the cargo and parachute center of gravity may now be constructed on the drawing. This is done by laying off a distance along the velocity vector which is equal to the sum of the lengths of the risers, riser extensions, suspension lines, and location of the parachute canopy center of gravity. The initial conditions have now been determined so that the semigraphical analysis may proceed.

3—27.3.2.2 Parachute Opening. The variation of force versus time during parachute opening will significantly affect the trajectory. This variation of force-time will depend on the following characteristics of the parachute:

a. Initial reefing configuration and reefing time delay.

b. Drag area growth from disreef to full canopy opening.

Drag produced during the reefed stage may be calculated by using the drag area ratio, calculated by the method of par. **3—15.1.6** or Reference **18,** as a multiplying factor in Eq. **3—30.** This drag area ratio may be applied in Eq. **3—30** for each time increment within the reefing time delay period, which starts at the end of parachute deployment time. From the time of disreef until full canopy opening, the drag area ratio varies with time and, thus, must be changed for each time increment in the analysis. Unfortunately, accurate drag area ratio-time relationships for particular parachutes may not always be available. For the present the techniques for calculating filling times as given in Reference **41** may be used to determine the drag area ratio-time relationships for large cargo parachutes. The value of the drag area ratio may then be varied for the corresponding time increments in the trajectory analysis and the drag force may be calculated using Eq. **3—30.** When the canopy inflates fully, the drag area ratio is equal to **1.0** and the drag area will then remain constant and equal to $C_D S_o$ until impact. (If the force-time history of the parachute during opening is available from experimental data, the force corresponding to each time increment may, of course, be used directly in the analysis.)

3—27.4 SNATCH FORCE AND OPENING SHOCK. During parachute deployment, two significant forces develop from the opening characteristics of the parachute. These are snatch force and opening shock. Opening shock has been given considerable attention with resulting reductions in this quantity by special reefing, venting, collapsing, or squidding canopy designs. Snatch force is much more difficult to control, however, and remains a limiting factor on parachute operation.

3—27.4.1 Snatch Force. Snatch force is described as that force that is developed by the acceleration of the parachute mass from its velocity at suspension line extension (prior to any elongation) to the velocity of the suspended load. If this velocity change is V, then the energy exchange is expressed by

$$\Delta E = (1/2) m_p V^2 \qquad \textbf{(3—31)}$$

where

m_p = mass of canopy cloth area and suspension lines across the cloth area, slug.

If no special shock absorbers are installed, the force must be transmitted through the suspension lines. Being elastic, the lines extend and transmit a tractive force on the drag-producing surface and the suspended load.

Thus,

$$\Delta E = \int_{L}^{L + \Delta L} P dL \tag{3—32}$$

where

P = momentary tractive force in the suspension lines, lb

L = unstretched suspension line length, ft

dL = suspension line stretch, ft.

In order to integrate the above equation, the force must be written as some function of the length. It may be possible to obtain such an equation from the force-elongation curves of the various suspension line materials. However, if the force-elongation curve cannot be expressed in an equation, a first approximation of linearity may be assumed. The following equation may then be written

$$P = \frac{ZP'}{\xi'} \tag{3—33}$$

where

Z = number of suspension lines

P' = breaking strength of suspension lines, lb

ξ = elongation of suspension lines, percent

ξ' = elongation of suspension lines at P', percent.

Since

$$L + \Delta L = L + \xi L$$

then $dL = L\,d\xi$

and kinetic energy may be expressed as

$$\Delta E = L \frac{ZP'}{\xi'} \int \xi\, d\xi \tag{3—34}$$

and, after integration, becomes

$$\Delta E = 1/2\ L \frac{ZP'}{\xi'} \xi^2 \tag{3—35}$$

Combining Eqs. **3—31, 3—33,** and **3—35** yields

$$P = \sqrt{\frac{m_p V^2 ZP'}{L \xi'}} \tag{3—36}$$

so that the snatch force P is expressed as a function of the differential velocity V.

The differential velocity can be found with the following equations

$$L = \frac{1}{J_b} \ln (1 + J_b V_d t_2) - \frac{1}{J_p} \ln (1 + J_p V_d t_2) \tag{3—37}$$

where

L = unstretched suspension line length, ft

t_2 = time for bodies to separate distance L, sec

V_d = deployment velocity, ft sec

$$J_b = \frac{\rho (C_{D_o} S)_b}{2 m_b}$$

Time t_2 can be found from Eq. **3—37** by a trial-and-error method. Once t_2 is known, the velocities of the suspended load V_1 and the parachute mass V_2 may be found from

$$V_1 = \frac{V_d}{J_b V_d t_2 + 1} \tag{3—38}$$

and

$$V_2 = \frac{V_d}{J_p V_d t_2 + 1} \tag{3—39}$$

The subscript b in above equations refers to suspended body and subscript p refers to the parachute mass.

A step-by-step procedure for calculation of the snatch force from the above equations can be found in Reference 18.

Snatch force may be reduced by one or more of the following techniques:

a. The drag area, $C_{D_o}S$, of the uninflated canopy and pilot chute, when applicable, can be reduced to a minimum.

b. Control of inflation tendencies may be accomplished by use of a device known as a skirt hesitator, which restricts the skirt of the canopy and prevents canopy inflation until the completion of line snatch.

c. Decreasing suspension line length will reduce snatch forces.

d. Use of suspension line, with high elongation, will decrease the peak force at snatch.

e. Minimizing canopy weight will reduce snatch force.

f. Packing the canopy so that only portions are accelerated at a given time.

3–27.4.2 Opening Shock. The determination of the filling time and opening shock of textile parachute canopies by mathematical processes, based upon an analysis of the physical process of canopy opening, has not yet been solved satisfactorily. Two different cases can be considered in the analysis of the dynamics of canopy opening. One, the "infinite mass" condition, stipulates that the velocity of the parachute-load configuration does not change appreciably during the period of canopy inflation and can therefore be considered constant. The other case, the "finite mass" condition, stipulates that the velocity decay during the inflation is substantial and must, therefore, be considered. In general practice, the infinite mass condition can be assumed to exist if the canopy drag loading ($W/C_{D_o}S$) is larger than 30 lb/ft^2, which means that the terminal velocity of the configuration at sea-level density will be greater than 150 ft/sec.

A second major factor affecting opening shock is the porosity of the canopy cloth.

3–27.4.2.1 The Finite Mass System. To determine the opening shock for the finite mass system, the filling time of the parachute must first be determined. One method[18] gives the instantaneous mouth diameter D of the canopy as

$$D = \frac{2D_o}{\pi}\left[\frac{2L\,\tau^{1/2}}{2L + D_o - D_o\tau^{1/2}}\right] \qquad (3\text{–}40)$$

where

D_o = circumferential diameter of the fully inflated parachute, ft

L = suspension line length, ft

$\tau = \frac{t}{t_f} = \frac{\text{time}}{\text{time for full inflation}}$

Time for full inflation t_f can be found from

$$\frac{dv}{d\tau} = \frac{D_o^2}{\pi}\, t_f\, V\left[(1-\tau)\,\tau^{4/3} - 2C_e\,\tau\,(1-\tau)\right] \qquad (3\text{–}41)$$

where

C_e = effective porosity of canopy fabric

V = free stream velocity, ft/sec

v = canopy volume, ft^3.

The volume ratio of the partially inflated canopy to the fully inflated canopy can be expressed by

$$\frac{v}{v_{max}} = \pi\tau\left\{\left[\frac{1}{4} - \frac{2}{\left(3-\sqrt{\tau}\right)^3}\right]\cdot \sqrt{\left(3-\sqrt{\tau}\right)^2 - \frac{4}{\pi^2}\tau} + \frac{1}{\pi}\sqrt{\tau}\right\} \qquad (3\text{–}42)$$

where

$$v_{max} = \frac{2D_o^3}{3\pi^2}$$

A simpler, close approximation for Eq. 3–42 is given by

$$\frac{v}{v_{max}} = 1.058 - \frac{(\tau - 1.31)^2}{1.62} \qquad (3\text{–}43)$$

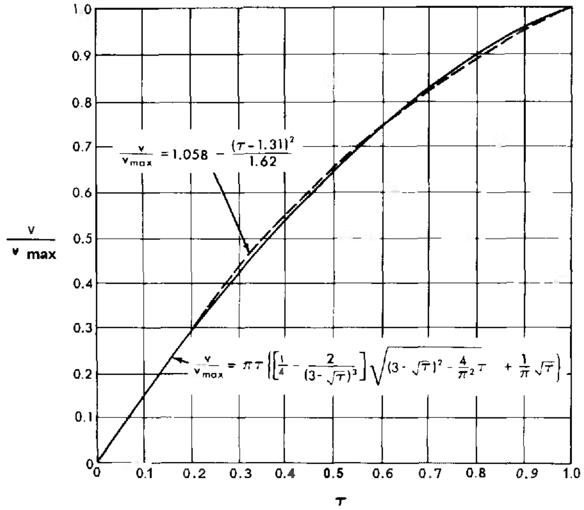


FIGURE 3-97. CANOPY VOLUME DURING INFLATION

Both of these curves are plotted in Fig. 3-97. The included mass of air in the canopy m_i can be determined from

$$m_i = \rho v \tag{3-44}$$

This is an important factor in determining opening shock. For example, at sea level the included mass of air in a canopy with a nominal diameter of 60 feet is 1119 pounds.

The apparent mass m_a which results from the transfer of energy to the surrounding air by a body moving through the air, is found from

$$m_a = \frac{\rho D_o^3}{4\pi^2} \tau^{5/2} \tag{3-45}$$

The total mass m or the sum of the suspended mass, the included-air mass, and the apparent mass can be expressed as

$$m = \frac{W}{g} + m_i + m_a \tag{3-46}$$

Making substitutions into Newton's Second Law of Motion

$$F = \frac{d(mV)}{dt} \tag{3-47}$$

and making several simplifications, the instantaneous velocity V can be expressed by

$$V = \frac{V_s}{\frac{BV_s}{2(11.25)} \left[(11.25\tau + A) \ln \left(\frac{11.25\tau + A}{A} \right) - 11.25\tau \right] + \frac{11.25\tau + A}{A}} \tag{3-48}$$

where

V_s = velocity at beginning of inflation, ft/sec

$$A = \frac{W \times 10^6}{20 g\, \sigma\, D_o^3}$$

$$\sigma = \text{density ratio} = \frac{\rho}{\rho_o} = \frac{\text{density of air at given altitude, slug/ft}^3}{\text{density of air at sea level, 0.00238 slug/ft}^3}$$

$$B = \frac{120(C_D S)_{max}\, t_f}{D_o^3}$$

Finally, the filling time for the finite mass case can be determined from

$$\int_0^{V_{max}} dV = \int_0^1 \left\{ \frac{D_o^2 t_f V_s}{\pi} \left[(1-\tau)\tau^{4/3} - 2C_e\tau\,(1-\tau) \right] d\tau \right\} \div \left\{ \frac{BV_s}{2(11.25)^2} \right. \tag{3—49}$$

$$\left. \left[(11.25\tau + A) \ln \frac{11.25\tau + A}{A} - 11.25\tau \right] + \frac{11.25\tau + A}{A} \right\}$$

A procedure for integrating the above expression numerically can be found in Reference 18.

The opening shock of the system can now be found from Newton's Second Law of Motion

$$F = \frac{-W}{g}\frac{dV}{dt} \tag{3—50}$$

or substituting from previous equations

$$F = \frac{WV}{2gt_f}\left(\frac{22.5(+B\tau V}{A + 11.25\tau}\right) \tag{3—51}$$

It is not possible to find the maximum force (the parachute opening shock) directly from Eq. 3—51. Therefore, using the value of t_f found by the analytical method described above, the value of F is calculated for τ ranging from 0 to 1 in intervals of 0.1. The history of force versus time of the canopy can then be plotted, and the maximum force can be determined.

3—27.4.2.2 The Infinite *Mass* System. The analysis for this time system is not as complicated as the finite mass system because the velocity during the period of canopy opening does not change.

Filling time for canopies with solid cloth can be determined from

$$t_f = \frac{2D_o}{3\pi V_s\left(\frac{9}{70} - \frac{C_e}{3}\right)} \tag{3—52}$$

Empirical values must be used to determine filling times of canopies with geometric porosity. Figure 3—98 presents such values.

The opening shock experienced by the canopy can be obtained from the filling time by the same method as presented for the finite mass case. However, if only the opening shock is required knowledge, the calculation of the maximum force of canopies for the infinite mass case can be very much simplified if based upon experimental values.

The drag force F_D obtained at constant velocity with a fully inflated canopy is expressed as

$$F_D = C_D S_o q_s \tag{3—53}$$

where

q_s = impact pressure corresponding to the velocity at snatch force, lb/ft^2.

If X is an amplification factor denoting the relationship between maximum opening force F_{max} and the constant drag force F_D expressed as

$$X = \frac{F_{max}}{F_D} \tag{3—54}$$

then the maximum opening shock or opening force is

$$F_{max} = C_D S_o q_s X \tag{3—55}$$

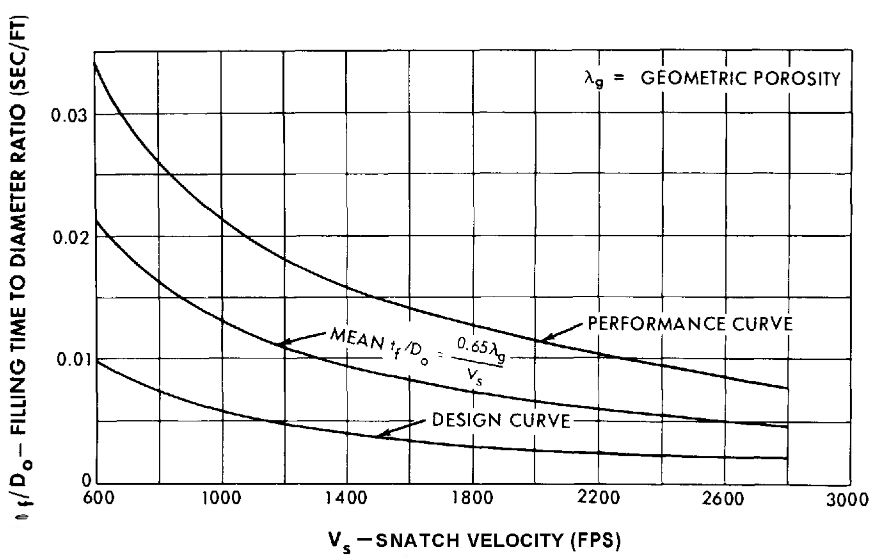


FIGURE 3-98. VARIATION OF RATIO OF FILLING TIME TO DIAMETER WITH SNATCH VELOCITY

where X is a dimensionless factor, the value of which has been established experimentally for various types of canopies.

X-factors have been determined from subsonic tests with practically infinite load and no appreciable velocity decrease during the period of canopy opening (wind-tunnel tests, aircraft deceleration, and drop tests under conditions of very high ratios of weight to drag area). For infinite mass conditions, the X-factor is a constant for a specific canopy type and has been found not to change with altitude of operation.

Typical X-factor values for specific canopy types are:

a. Solid cloth, flat circular: $X \geq 2.0$

b. Solid cloth, extended-skirt: $X \geq 1.8$

c. Ribbon: $X \geq 1.1$

d. Ring-slot: $X \geq 1.05$

e. Shaped gore and conical: X somewhat lower than for comparable canopy designs.

3—27.4.3 Recent Developments. The above derivations for snatch force and opening shock are taken from Reference 18 and have been summarized herein to give the reader an appreciation for the physical process of parachute deployment and opening. It should be noted, however, that these are traditional methods which were originally developed for personnel size parachutes and, as such, care must be exercised in applying them to cargo parachutes. It has been found, for instance, that the given expressions for filing time yield results for large cargo parachutes which differ from observed times. Recent efforts have resulted in the establishment of empirical expressions for the determination of filling time based on test observations. These are given in Reference 41 and may be used for calculation of filling times for large cargo parachutes. Reference 40 tabulates calculated values for several standard parachutes based on the expressions.

3—28 DESCENT PHASE

3—28.1 TERMINAL VELOCITY. The descent phase may be defined as that portion of the airdrop environment beginning immediately after full deployment of the recovery parachute(s) and ending immediately before impact. A terminal velocity of 28.5 feet per second is specified for low velocity airdrop. The terminal velocity experienced in a high velocity airdrop is usually 70 to 90 feet per second. High velocity airdrop provides a greater degree of accuracy since it is less susceptible to the effects of wind currents (Fig. **3—99).** The terminal velocity of a load is determined by the type and number of recovery parachutes used. **Figure** 3—100 is a plot of load weight versus terminal velocity as used in the computed air release point **(CARP)** system **of** airdrop. The terminal velocities shown on **Fig.** 3—100 are based on standard day **at** sea

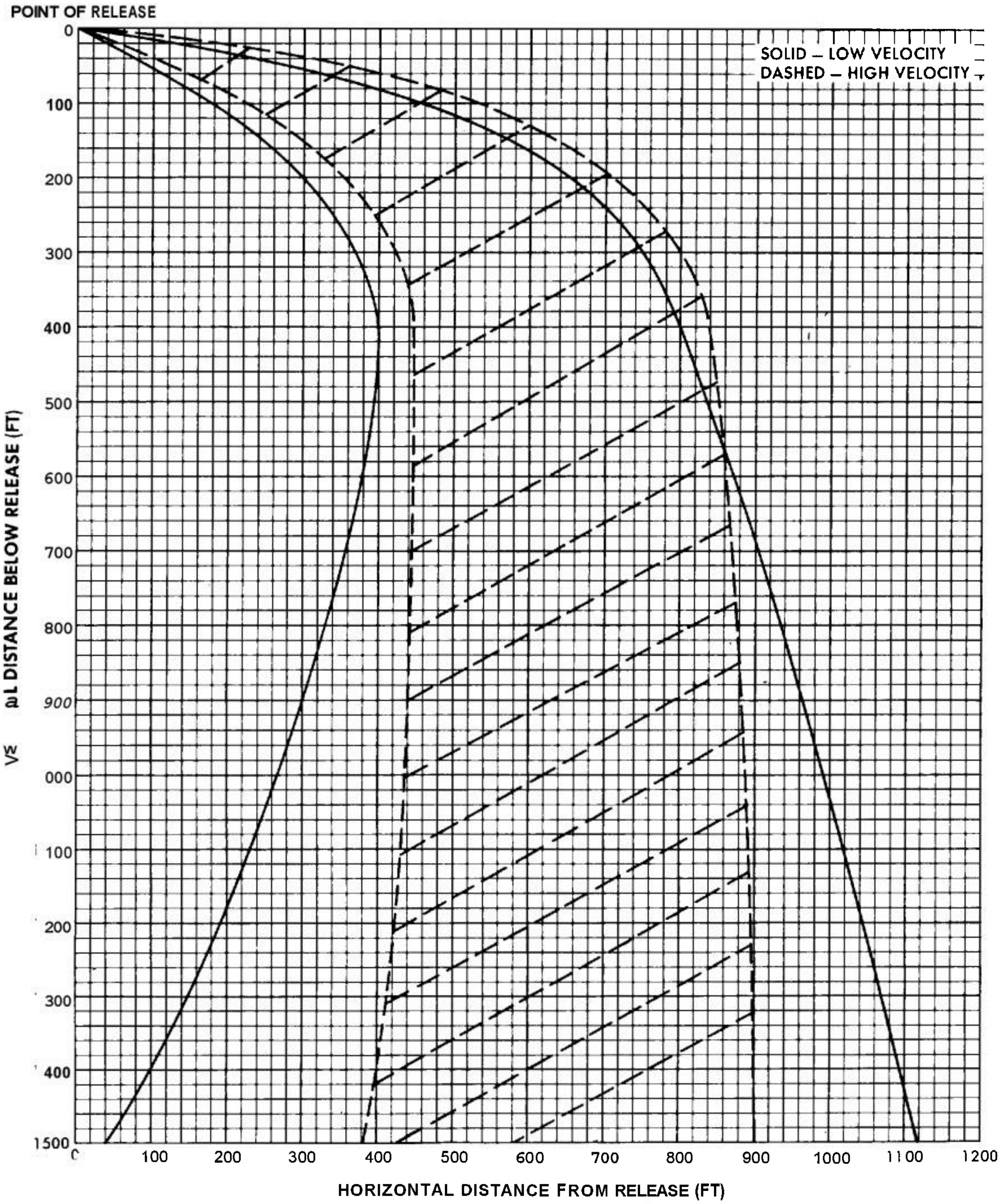


FIGURE 3–99. TYPICAL LOAD TRAJECTORY SHOWING EFFECTS OF WIND CURRENTS

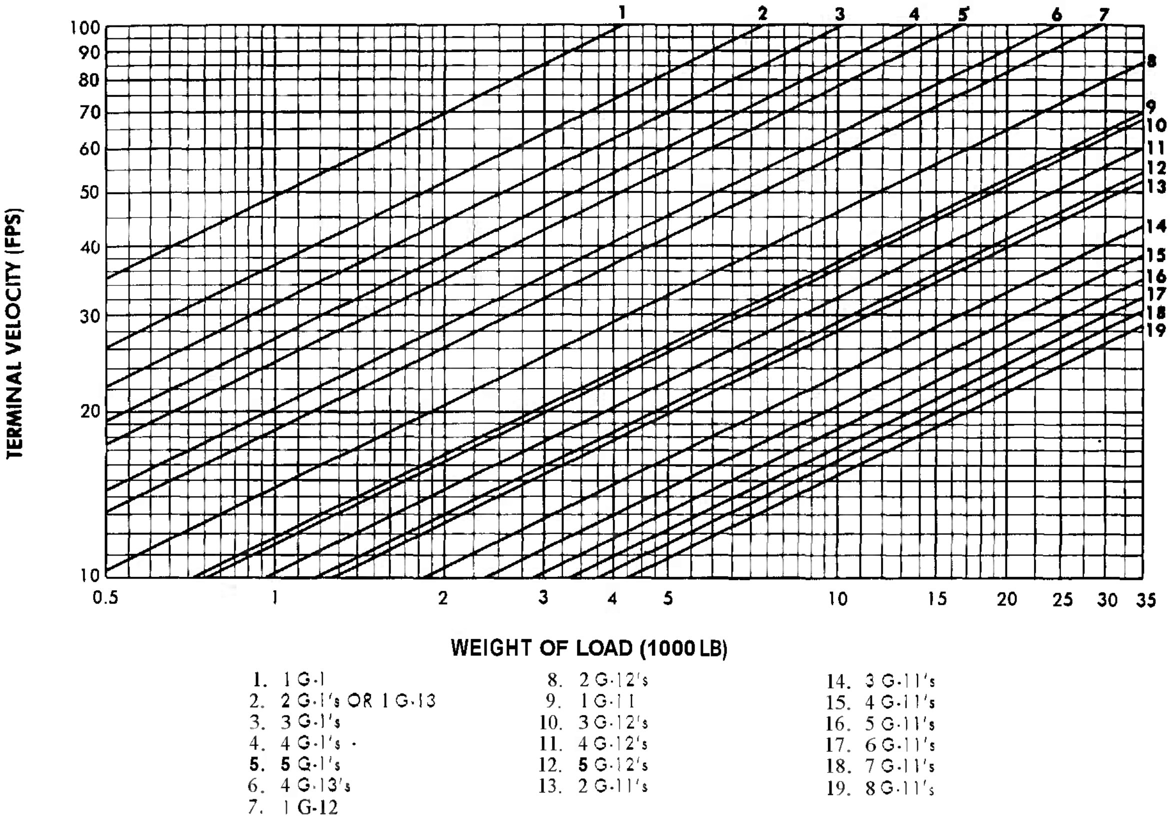


FIGURE 3–100. TERMINAL VELOCITY VS LOAD WEIGHT (STANDARD DAY)

level and are determined by the terminal velocity equation

$$V = \sqrt{\frac{2W}{NF_{CD}\rho_o C_{D_o} S_o}} \qquad (3\text{—}56)$$

where

V = terminal velocity, ft/sec

N = total number of parachutes in cluster

F_{CD} = cluster factor as determined from Fig. 3—30

ρ_o = density of air at sea level, 0.00238 slug/ft^3

C_{D_o} – drag coefficient (0.75 for all parachutes listed)

$$S_o = \frac{\pi D_o^2}{4}, \text{ ft}^2$$

D_o = nominal diameter of parachute, ft.

For other altitudes, values obtained should be modified by multiplying by

$\frac{1}{\sqrt{\sigma}}$ where

$$\sigma = \text{density ratio} = \frac{\rho}{\rho_o}$$

and ρ = density of air at given altitude, slug/ft^3.

3—28.2 MALFUNCTION VELOCITIES OF HAZARDOUS MATERIAL. Approximately 1 to 2 percent of all equipment drops can be expected to malfunction. A malfunctioned load can be expected to reach a terminal velocity of 130 to 150 feet per second. Some items, such as ammunition, explosives, fuel, etc, should be able to withstand impact at malfunction velocities without contaminating the area by fire or explosion[29]. The material subjected to this high terminal velocity may be unserviceable.

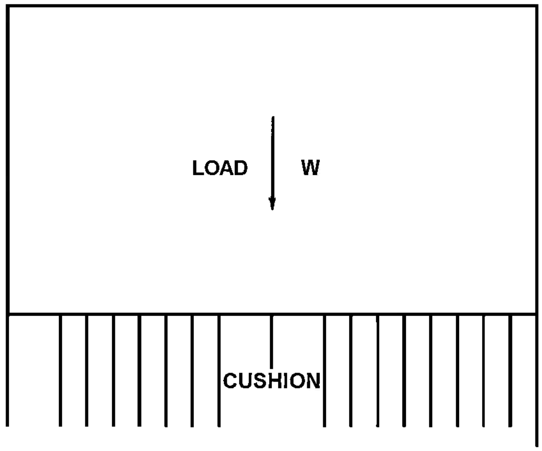
3–29 IMPACT PHASE

As previously stated, ground impact provides the most severe environment to which a dropped load is subjected. The energy dissipater system must reduce the severity of that environment to a level acceptable to the item being dropped. Standards have been developed for use in design of materiel to be airdropped[28]. Conformance with these standards eliminates many of the problems encountered when designing an energy dissipater system for a new item.

3–29.1 SHOCK CRITERIA FOR AIRDROP MATERIEL. Each item which is to be airdropped shall be designed to accommodate the current energy dissipater system. The current system specifies a value of 18.5 for the term G when G equals the number of g's deceleration. When applied, this means the item must withstand a deceleration force of 19.5 times its airdrop weight — $W(G+1)$ — when decelerated from 28.5 feet per second to zero feet per second on ground impact. The item shall comply with the applicable end item specification after impact.

3–29.2 DESIGN CRITERIA FOR ENERGY DISSIPATER CONFIGURATIONS. All materials deform to some degree when subjected to load and consequently are capable of absorbing energy. When cushioning an item against a sudden impact load, it is necessary to dissipate this energy in such a way as to prevent damage to the item. Since airdrop presents a "single impact" problem, an energy dissipater system can be devised which uses a crushable material that dissipates energy by the mechanics of permanent deformation.

3–29.2.1 Theory of Cushioning. The theory of cushioning is explained by the relation between the forces applied to a mass and the acceleration of the mass. These factors are governed by Newton's Second Law of Motion



$F = SA$

FIGURE 3–101. MASS IMPACTING CUSHION

$$F_r = ma \quad (3\text{–}57)$$

where

F_r = the resultant force applied to the mass, lb

$m = \dfrac{W}{g}$ = mass, slug

W = weight of mass, lb

a = acceleration of center of gravity of mass, ft/sec^2

g = acceleration due to gravity = 32.2 ft/sec^2.

This equation may also be written

$$F_r = WG \quad (3\text{–}58)$$

where

$G = \dfrac{a}{g}$ = level of acceleration compared to gravitational acceleration (a dimensionless number).

For example, in Fig. 3–101, if F is greater than W, the mass is instantaneously being accelerated upward due to the combined forces of F and W and

$$F - W = \frac{Wa}{g} = WG \qquad (3\text{—}59)$$

or

$$F = SA = W(G + 1) \qquad (3\text{—}60)$$

where

S = the instantaneous stress in the cushion, lb/ft^2

A = effective area of cushion, ft^2.

3—29.2.2 Properties of Cushioning Materials. Before an energy dissipater system can be designed, it is necessary to know the stress-strain properties of the cushioning material to be used. Paper honeycomb of the type specified for standard airdrop systems can be expected to crush at a reasonably constant dynamic stress of 6000 pounds per square foot. However, the stresses begin to rise sharply at 70 to 80 percent strain as the material begins to bottom. Therefore, the optimum or design strain is specified as 70 percent.

***3—29.2.3* Energy Dissipater System for a Hypothetical load.** To design an energy dissipater system for an item, it is necessary to know the weight of the item rigged for airdrop W, the specified maximum allowable deceleration or load factor *G*, and the impact velocity V or equivalent drop height h.

The maximum allowable G loading is a convenient quantity for introducing the ruggedness or lack of ruggedness of the item into the cushioning design. This value is usually determined by a series of test drops using successively higher values until the maximum allowable value is determined. Figure 3—102 is a plot of load factor versus stopping distance for various rates of descent.

The impact velocity is the terminal velocity of the dropped item. An equivalent drop height is that height from which the item must be dropped in free fall to attain the same impact velocity experienced in a parachute drop.

In par. 3—29.2.1, it was seen that

$$F = SA = W(G + 1). \qquad (3\text{—}60)$$

If S_a is the average dynamic crushing stress of the cushioning material to be used, the required area of the energy dissipater will be

$$A = \frac{W(G + 1)}{S_a} \qquad (3\text{—}61)$$

Figures 3—103 through 3—107 plot this equation for various values of G. Note that G is a function of item weight, dissipater area, and crushing stress only. It is *not* a function of impact velocity when sufficient thickness as calculated below is provided to prevent bottoming.

By relating the potential energy of the dropped item to the energy absorbed per unit volume of cushioning material, the necessary thickness of cushioning material is determined to be

$$T = \frac{h}{G\epsilon} \qquad (3\text{—}62)$$

where

T = thickness of cushioning material, ft

h = equivalent drop height, ft

G = load factor

ϵ = design strain of cushioning material (0.7 for paper honeycomb).

Since the impact velocity is related to drop height by

$$V^2 = 2gh \qquad (3\text{—}63)$$

Eq. 3—62 can be represented as

$$T = \frac{V^2}{2gG\epsilon} \qquad (3\text{—}64)$$

where

V = impact velocity, ft/sec

g = acceleration due to gravity = 32.2 ft/sec^2.

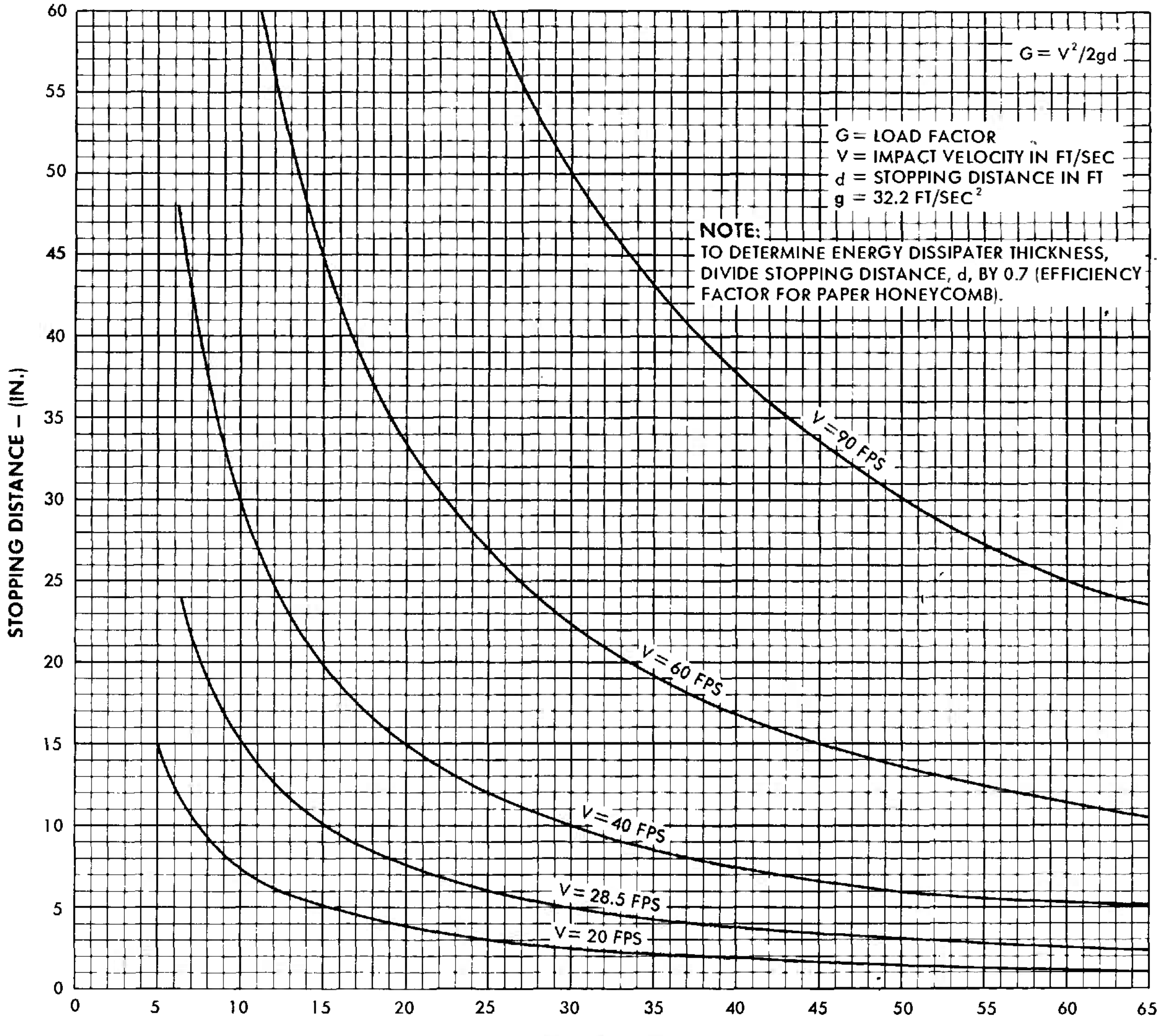


FIGURE 3-102. LOAD FACTOR VS STOPPING DISTANCE FOR VARIOUS RATES OF DESCENT

If the required thickness is not an integral multiple of the available paper honeycomb pad thickness (3 inches), the cushion should be built up to the next integral pad thickness to protect against bottoming.

Complex items, such as vehicles, require that attention be given to components within the item. Some components, such as tires and springs, will deform and absorb energy, returning most of the energy as rebound. Consequently, it is undesirable for these members to have large deformations. Heavy components require special consideration since movement of these components can cause damage to connecting parts. The use of load spreaders and proper system design will eliminate these problems.

3–29.2.4 Energy Dissipater System for a Standard load. Complete requirements have been developed for design and application of an energy dissipater system for a standard load[28]. For standard, low velocity airdrops, a terminal velocity of **28.5** feet per second is specified. **A** design value of **18.5** has been assigned for G. This value is based on **a** desired maximum dissipater stack height

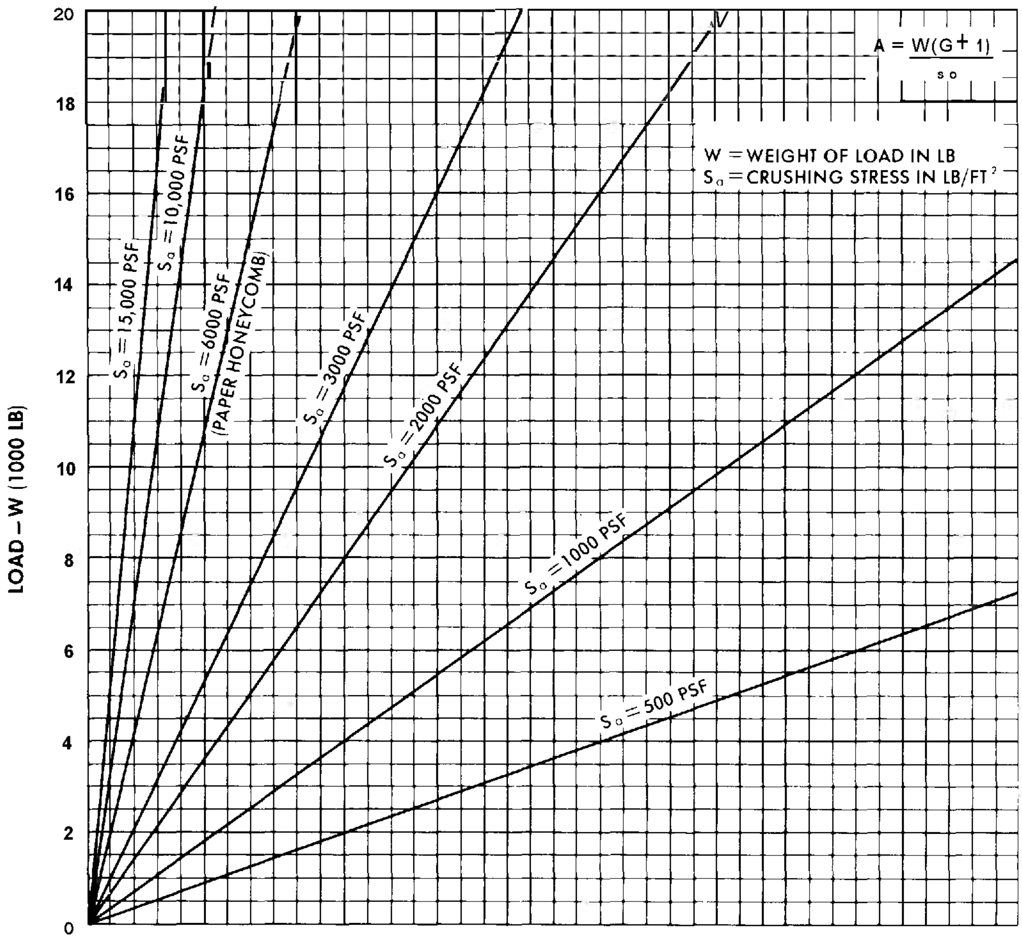


FIGURE 3–103. EFFECTIVE AREA VS LOAD FOR VARIOUS CRUSHING STRESSES (G = 10)

of 12 inches and the results of investigation of military items requiring airdrop. The deceleration force of G + 1 or 19.5 times the item airdrop weight is met by using 3.25 square feet of paper honeycomb crushing area for each 1000 pounds of item airdrop weight. The 12-inch thickness of paper honeycomb is composed of four layers of 3-inch thick panels with a dynamic crushing stress of 6000 pounds per square foot.

3—29.2.5 High Velocity Versus Low Velocity. Items dropped in high velocity airdrop experience an impact velocity of 70 to 90 feet per second as compared with *28.5* feet per second specified for low velocity airdrop. The above criteria of 18.5 *G* deceleration and 1-foot thickness should not be used for high velocity airdrop. To illustrate, by applying

$$T = \frac{V^2}{2gG\epsilon} \qquad (3\text{—}64)$$

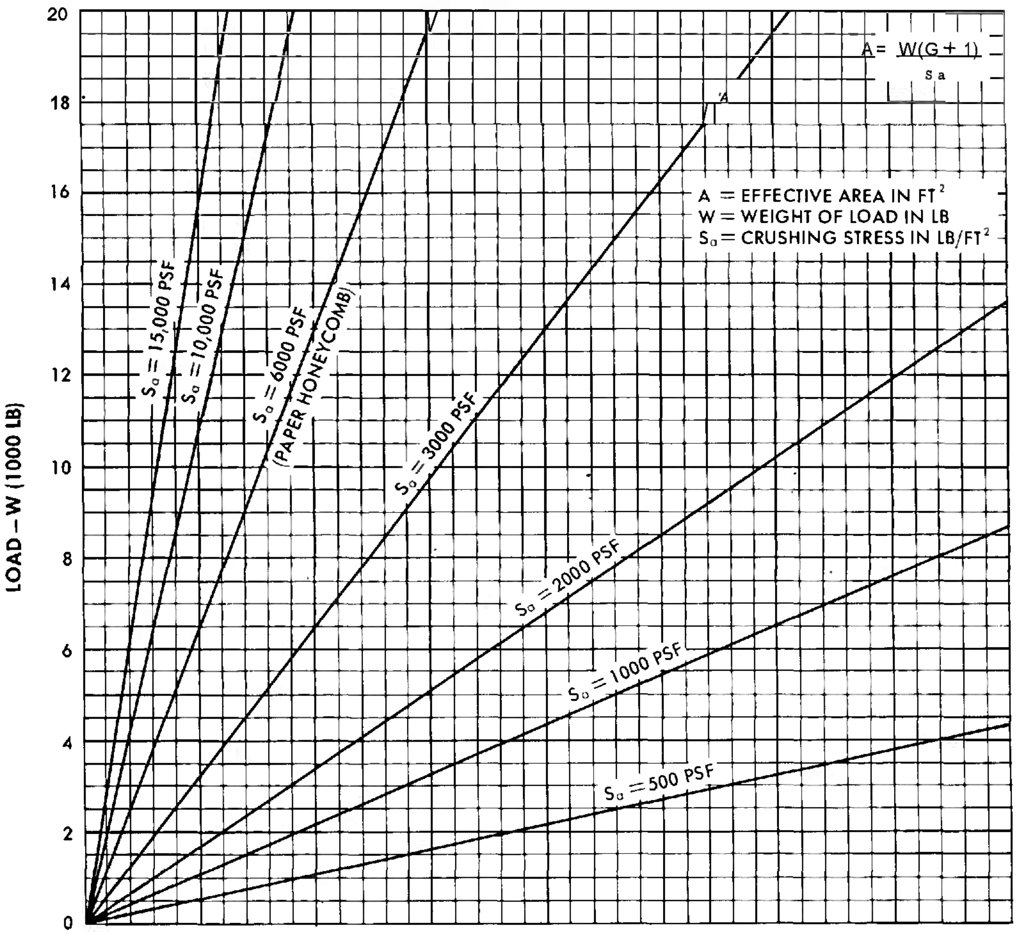
to a load having an impact velocity of 80 feet per second,

$$T = \frac{(80)^2}{2(32.2)\,(18.5)\,(0.7)}$$

or

T = 7.67 ft required thickness of paper honeycomb.

The design value of 18.5 assigned for G in a low velocity airdrop requires an impractical height of cushioning material when



ienced in a high velocity airdrop. Also, by applying

$$G = \frac{v^2}{2gd} \qquad (3\text{—}65)$$

where

v = impact velocity = 80 ft/sec

d = stopping distance = 0.7 ft for 1 ft thickness of paper honeycomb

then

$$G = \frac{(80)^2}{2(32.2)\,(0.7)}$$

$$G = 142.$$

The specified cushion height of 1 foot used in low velocity airdrop is also not practical for most items in a high velocity airdrop. High velocity airdrop should be limited to items that will withstand a higher deceleration force than that specified for low velocity airdrop in order to accommodate a practical energy dissipater system. A value of 60 for G will yield a dissipater thickness under 2.5 feet and is suggested as a reasonable initial test configuration.

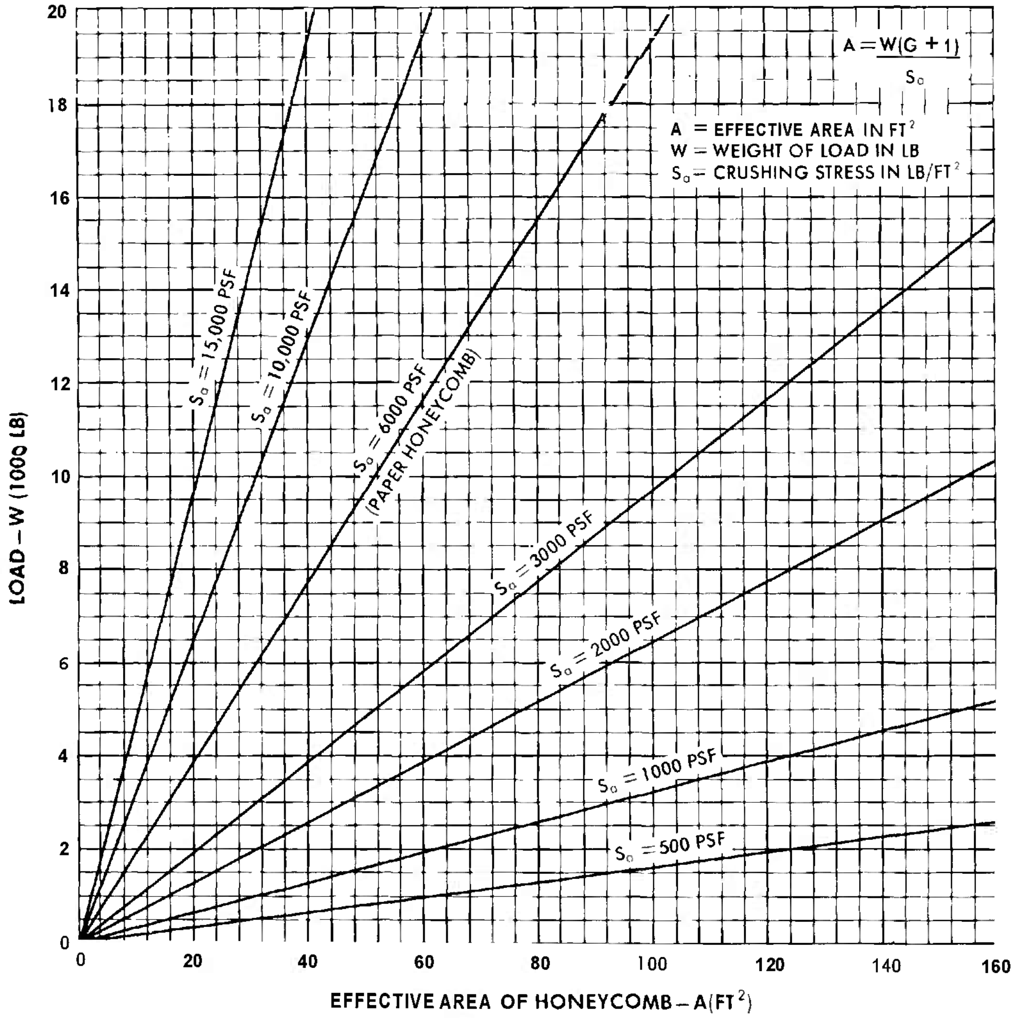


FIGURE 3–105. EFFECTIVE AREA VS LOAD FOR VARIOUS CRUSHING STRESSES (G = 30)

3–29.3 TEST METHODS — SIMULATED AIRDROP IMPACT. Initial tests should be made with deceleration force levels less than the $G + 1$ level specified in the system design, while retaining the design thickness of cushioning material. Lower deceleration force levels are specified for the initial tests to preclude damage to the test item. Final tests should be conducted with the item rigged on a skid or platform with the design number and sizes of dissipater stacks and load spreaders, if required (Fig. **3—108**). The item should be free-dropped from a height producing the same impact velocity that would be experienced in airdrop. The drop height should be measured from the bottom of the skid or platform to the impact surface. The impact surface should be concrete, with the skid or platform striking the surface at an angle of not greater than 2.5 degrees in any direction. The test item, after impact, must meet the performance requirements of the applicable end item specification.

3—29.3.1 Sample Test Plan. Assume that a 20,000-pound load is to be test dropped and the deceleration level selected for the initial drop is 8 g's. (A value of 7 to 10 g's is reasonable for initial test drops of most

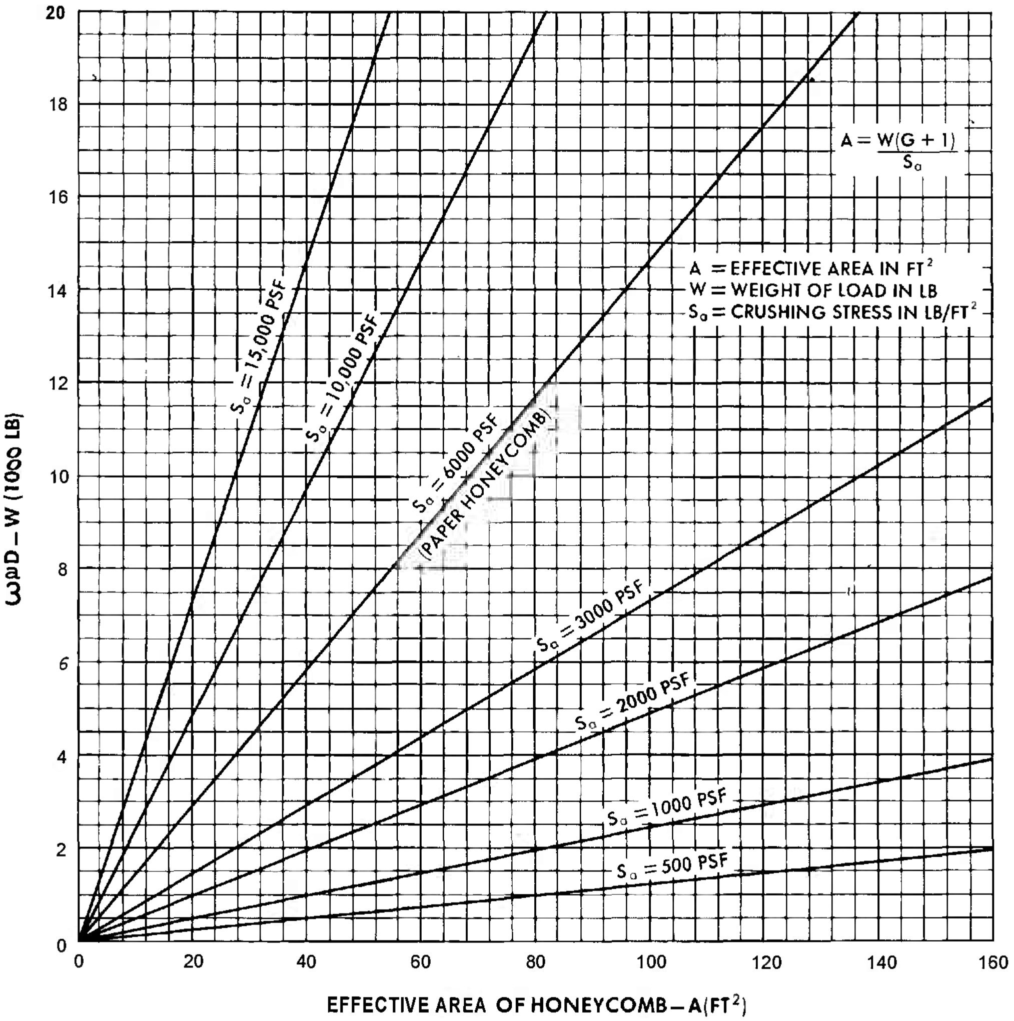


FIGURE 3–106. EFFECTIVE AREA VS LOAD FOR VARIOUS CRUSHING STRESSES (G = 40)

Army equipment.) Calculate the area of paper honeycomb required by

$$A = \frac{W(G + 1)}{S_a}$$

where

W = rigged weight of load = 20,000 lb

G = 8

S_a = average dynamic crushing stress of paper honeycomb = 6000 lb/ft^2

$$A = \frac{20{,}000\,(8 + 1)}{6000}$$

A = **30** sq ft.

The total area of paper honeycomb to be distributed under the load is **30** square feet. The dissipater area should be apportioned beneath the item according to the weight distribution and maximum strength areas of the item. **A** trial and error method **may** be used so that, by the time the final configuration is reached, **all** honeycomb stacks are crushing uniformly.

Calculate the impact velocity necessary to preclude exceeding 70 percent strain on the 1-foot thickness of paper honeycomb by

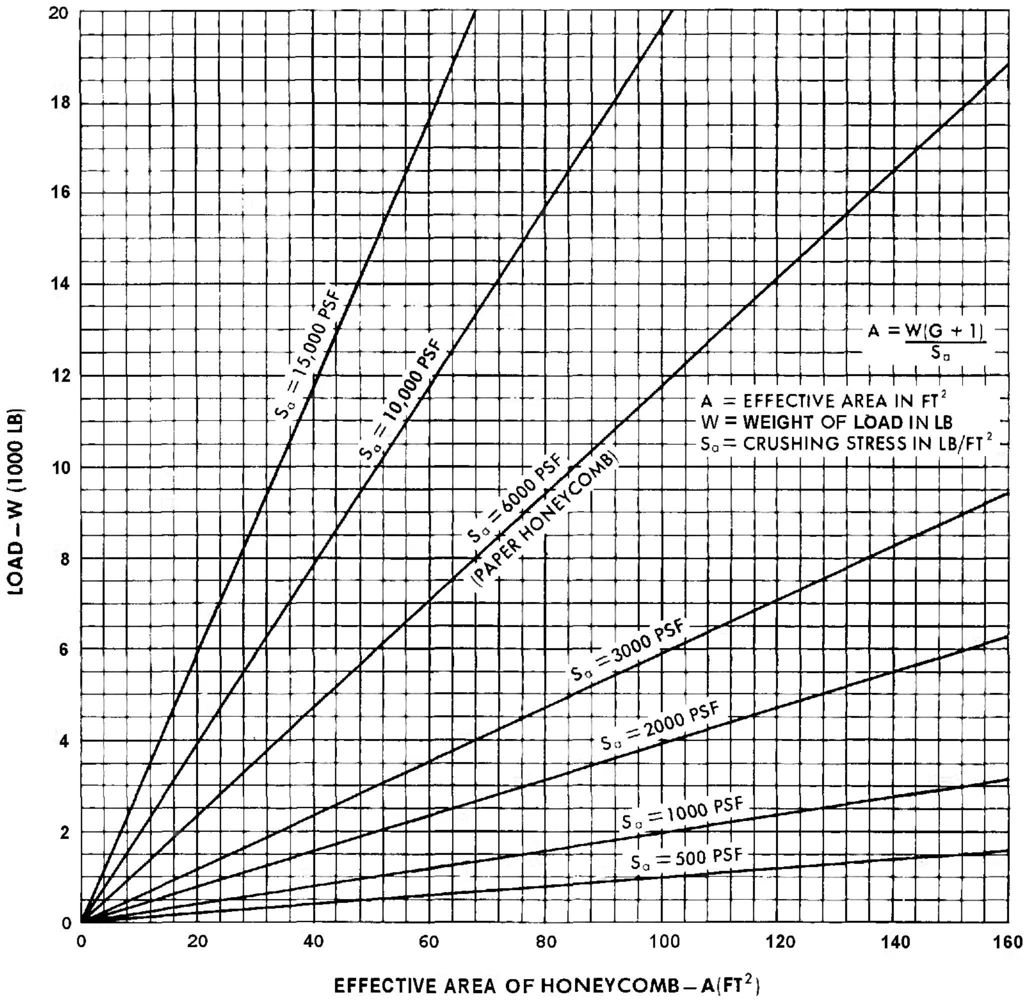


FIGURE 3-107. EFFECTIVE AREA VS LOAD FOR VARIOUS CRUSHING STRESSES (G = 50)

$$V = \sqrt{2gG\epsilon T} \qquad (3\text{–}66)$$

where

g = acceleration due to gravity = 32.2 ft/sec^2

G = 8

ϵ = design strain of paper honeycomb = 0.7

T = thickness of paper honeycomb = 1 ft

$$V = \sqrt{2(32.2)\,(8)(0.7)\,(1)}$$

$$V = \sqrt{4360.64}$$

$$V = 19 \text{ ft/sec.}$$

The required impact velocity is 19 feet per second.

Calculate the equivalent drop height by

$$h = \frac{V^2}{2g} \qquad (3\text{–}67)$$

where

V = impact velocity = 19 ft/sec

g = acceleration due to gravity = 32.2 ft/sec^2

$$h = \frac{(19)^2}{2\,(32.2)}$$

$$h = 5.6 \text{ ft.}$$

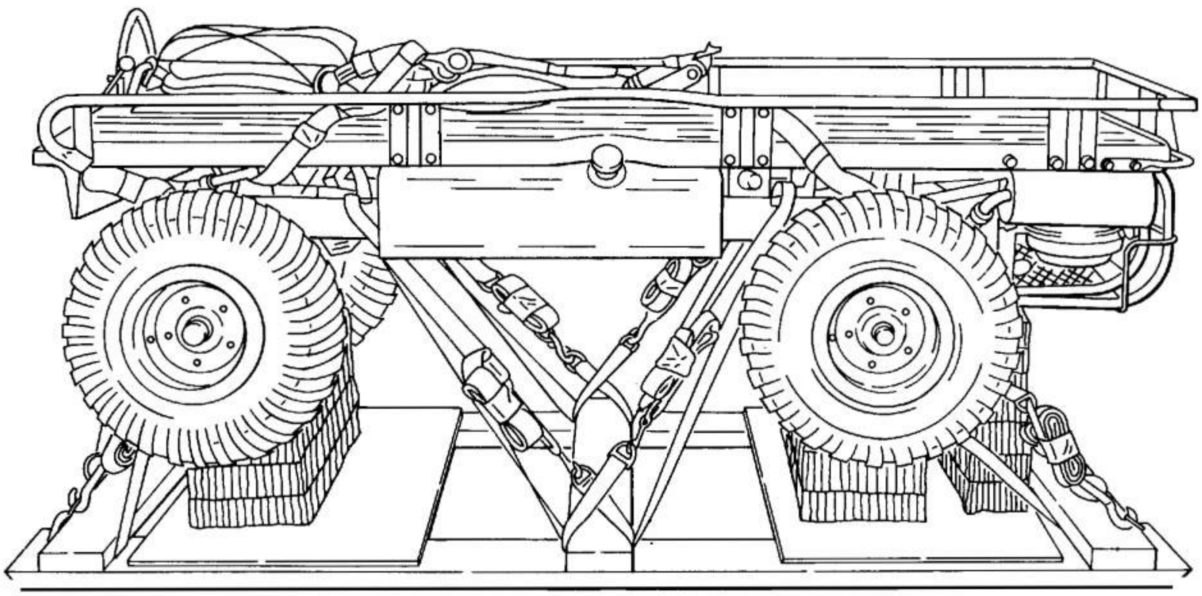


FIGURE 3-108. M274 WEAPONS CARRIER RIGGED FOR TEST DROP

The drop height, as measured from the bottom of the skid or platform to the impact surface, will be ***5.6*** feet.

If the initial drop is successful, the G level may then be increased in steps and the tests repeated until the final G level is reached without item damage and without evidence of bottoming. The increment of G to be selected for successive drops will be a matter of judgment, depending on the particular item structure and configuration. If damage occurs on an initial drop, the stacks of cushioning material should be shifted or modified as necessary and tests repeated at the same G level until Successful. If damage occurs after a number of drop tests, a new item should be dropped at the damaging *G* level to nullify any effects due to repeated impacts.

Another method of testing is to proceed as above, except keeping impact velocity constant. In this method, the G level is increased in increments while the dissipater stack height is decreased to its final configuration.

3—29.3.2 Instrumentation and Data Analysis Techniques. It has been found during numerous test drops of Army vehicles that, except for special cases, the use of extensive instrumentation is not too helpful". There are no analyses for the data to be compared with and there are also no analytical methods which would use the data to predict results under different test conditions. High-speed motion pictures in the range of 1000 to **4000** frames per second are useful in observing the relative motion between parts of the item during impact. The tests are primarily a series of drops with a visual inspection after each drop until either the dropped item fails or a suitable energy dissipater configuration is achieved.

3—29.4 EFFECTS OF DRIFT AND OSCILLATION ON IMPACT AND ENERGY DISSIPATION. Dropped loads are subject to varying degrees of drift and oscillation, depending upon wind conditions, rate of descent, etc. The effects of drift and oscillation on impact and energy dissipation are currently undergoing analysis.

3—30 AIRDROP TESTING — FLIGHT AND SIMULATED

3-30.1 PURPOSE AND OBJECTIVES. Test methods, test equipment, and instrumentation developed, or which have become available, during the last decade have been prime factors in establishing the design and performance characteristics of airdrop material. These same methods and test equipment will undoubtedly play a major part in the search for new concepts and the development of new items. Proper test methods and equipment make possible the most expeditious correction of design deficiencies and the economical transition to the stage of actual application. Table 3—10 is a summary of data acquisition and processing for both simulated and flight test of a heavy load.

3-30.2 GOVERNMENT TEST SITES AND FACILITIES. Test sites with a capability for conducting instrumented airdrop tests are located at the U. S. Army Yuma Proving Ground, Yuma, Arizona, and at the joint Air Force-Navy Facility at El Centro, California. These two sites are the only Government test sites with complete and sophisticated facilities for conduct of engineering design tests for flight tests of the entire range of supply and equipment weights. Instrumented static drop test facilities for simulated airdrop impact tests are maintained at the U. S. Army Natick Laboratories, Natick, Massachusetts and at Yuma Proving Ground.

3—30.2.1 Static Drop Test Facilities. In general, static drop test facilities consist of a hoist and release mechanism, impact area, instrumentation, and control area. The hoisting mechanism is usually a crane fitted with a helicopter release hook on the hoist cable. The impact area for most tests in a flat reinforced concrete pad; however, drops can also be made on various textures and grades of earth. The instrumentation usually consists of high speed photography and various transducers, such as accelerometers and strain gages, which may be used to measure accelerations, forces, stress, and strains of the airdrop item during impact. The data are permanently recorded on magnetic tapes or oscillograph records, or by photographing an oscilloscope screen.

3—30.2.2 Airdrop Facilities. Instrumentation as used in typical engineering design flight tests consists of cinetheodolite and motion picture photography and telemetry and/or onboard data recording units. Cinetheodolites are highly accurate photographic instruments which are used at surveyed sites around the drop zone to continuously record the space position of an airdrop load during its trajectory. The resulting data can be reduced to provide space position, velocities and accelerations, and oscillation angles along three dimensional axes. A typical cinetheodolite tracking range is illustrated in Fig. 3—109.

Motion picture photography is used to record the airdrop from various positions on the ground, in the delivery aircraft, and from chase planes. The films are used mainly for qualitative analysis of the airdrop, although reasonably accurate quantitive data may sometimes be obtained for certain events in the airdrop sequence.

Radio telementry packages, mounted on the drop load and transmitting to ground-stationed recording equipment, may be used to obtain velocity and acceleration, snatch force and opening force, impact shock, stresses and strains, and event marks during extraction deployment and recovery of the airdrop load. Radio telemetry data may be time correlated with the cinetheodolite trajectory data to provide a complete record of important airdrop parameters for the entire sequence of events. Data may be corrected to zero wind and standard day conditions by application of meteorological data which are also recorded during the drop.

TABLE 3–10. DATA ACQUISITION **AND** PROCESSING SUMMARY

TEST PHASE	TEST DATA	POSSIBLE DATA APPLICATION	TEST METHOD			INSTRUMENTATION (A)		INSTRUMENTATION (B)			REMARKS	DESIRED DATA PRESENTATION	RECOMMENDED DATA PROCESSING METHOD
			(A)	(B)	OTHER	(1)	(2)	(3)	(4)	(5)			
1. GROUND OPERATIONS	A. Wt and CG of item	1. Determination of energy dissipater configuration.			Ground-station						Use multi-point weighing device.	Numerical values	Manual calculation
		2. Determination of item position on platform.											
		3. Determination of number and type of lashings required.											
	B. Wt and CG of rigged load	1. Determination of number and type of recovery and extraction parachutes required.			Ground-station						Use multi-point weighing device.	Vumerical values	Manual calculation
		2. Determination of load position in aircraft.											
		3. Determination of load trajectory.											
		4. Determination of tumbling characteristics of rigged load.											
		5. Determination of number and types of other droppable kit components.											
	C. Moments of inertia about principal axes of rigged load	1. Determination of tumbling characteristics of rigged load.			Ground-station						Use physical pendulum and bifilar pendulum and stop-watch.	Numerical values	Manual calculation
		2. Determination of over-turning characteristics of rigged load.											
		3. Determination of oscillation characteristics of rigged load.											

A) Static Drop (B) Flight Test (1) High-Speed Mc .on Pictures (2) Ground-Station Recording (3) Cinetheodolite
(4) Self-Recording 5) On-Board Recording

TABLE 3-10. DATA ACQUISITION AND PROCESSING SUMMARY (Cont)

TEST PHASE	TEST DATA	POSSIBLE DATA APPLICATION	TEST METHOD			INSTRUMENTATION						DESIRED DATA PRESENTATION	RECOMMENDED DATA PROCESSING METHOD
						(A)		(B)			REMARKS		
			(A)	(B)	OTHER	(1)	(2)	(3)	(4)	(5)			
I. GROUND OPERATIONS (Cont)	D. Stresses in platform due to ground handling	1. Determination of platform design criteria for ground handling loads.			Operational test						Strain gages and ground-station recording required.	Numerical values (critical stresses at given operational condition)	Manual calculation
	E. Deflections in platform due to ground handling	1. Determination of platform design criteria for ground handling loads. 2. Formulation of rigging techniques. 3. Establishment of ground handling techniques.			Operational test						Dial gages and still photos required.	Numerical values (critical deflections at given operational condition)	Direct read-out
	F. Loads developed in hardware during rigging	1. Determination of design criteria for air delivery hardware. 2. Formulation of rigging techniques.			Operational test						Load cells, strain gages, and ground-station recording required.	Numerical values (critical loads at given operational condition)	Manual calculation
	G. Procedures used to rig and load test items	1. Determination of effectiveness of special procedures and equipment to ease item rigging and loading workload.		x							Still photo. and motion pictures.	Tabulated remarks, photos	Direct read-out
II. EXTRACTION	A. Extraction force	1. Determination of tumbling characteristics of rigged load. 2. Determination of design criteria for air delivery components. 3. Determination of parachute drag force.		x					x	x	Also motion pictures.	Plot of force vs time	Automatic record reader

( ) Static Drop (B) Flight Test (1) High-speed Motion Pictures (2) Ground-Station Recording (3) Cinetheodolite
(4) Self-Recording (5) On-Board Recording

TABLE 3-10. DATA ACQUISITION AND PROCESSING SUMMARY (Cont)

TEST PHASE	TEST DATA	POSSIBLE DATA APPLICATION	TEST METHOD			INSTRUMENTATION (A)		INSTRUMENTATION (B)			REMARKS	DESIRED DATA PRESENTATION	RECOMMENDED DATA PROCESSING METHOD
			(A)	(B)	OTHER	(1)	(2)	(3)	(4)	(5)			
EXTRACTION (Cont)	B. Fore-and aft acceler-ation of platform	. Determination of tumbling characteristics of rigged load.		x					x	x	Also motion pictures and air-craft stationed equipment.	Plot of force vs time	Automatic record reader
	C. Exit velocity of plat-form	.. Determination of body motions of rigged load.		x							Velocity-measur-ing device such as motion pictures, photo cells, ve-locimeters or rate of extraction reel.	Numerical values	Manual calculation
	D. Stresses and de-flections of plat-form	.. Determination of platform and components design criteria.		x					x	x	Strain gages and ground-station recording may also be used.	Numerical values (critical stresses and critical deflections)	Manual calculation
	E. Stresses and de-flections of plat-form during simu-lated extrac-tion mal-function	1. Determination of platform and components design criteria.		x					x	x	Strain gages and ground-station re-cording may also be used.	Numerical values (critical stresses and critical de-flections)	Manual calculation
	F. Ex-traction se-quence times	1. Determination of body motions of rigged load.		x							Motion pictures and stop-watch.	Numerical values	Manual calculation

(A) Static Drop (B) Flight Test (1) High-speed Motion Pictures (2) Ground-Station Recording (3) Cinetheodolite (4) Self-Recording (5) On-Board Recording

TABLE 3-10. DATA ACQUISITION AND PROCESSING SUMMARY (Cont)

TEST PHASE	TEST DATA	POSSIBLE DATA APPLICATION	TEST METHOD			INSTRUMENTATION					REMARKS	DESIRED DATA PRESENTATION	RECOMMENDED DATA PROCESSING METHOD
						(A)		(B)					
			(A)	(B)	OTHER	(1)	(2)	(3)	(4)	(5)			
Extraction (Cont)	G. Forces in parachute lines	1. Determination of parachute deployment and opening performance.		x					x	x		Numerical values [critical loads)	Manual calculation
	H. Forces in extraction rigging	1. Determination of design criteria of static lines, shear knives, etc.		x					x	x		Numerical values (critical loads)	Manual calculation
III. RECOVERY	Trajectory data to specifically include:												
	A. Rotation of rigged load	1. Determination of body motions of rigged load.		x				x			Ground air motion pictures.	Rotation angle vs time	Automatic film processor
	B. Horizontal velocity of rigged load afte chute equilibrium	1. Determination of gliding characteristics of single and clustered cargo parachutes.		x				x				Plot of vector velocity vs altitude	Automatic film processor
	C. Orientation of platform during descent	1. Determination of effects of azimuth control devices upon orientation of platform.		x				x				Plot of azimuth angle vs altitude	Automatic film processor
	D. Equilibrium rate of descent	1. Determination of parachute performance due to such effects as clustering, presence of body wake, etc.		x				x				Plot of velocity vs altitude	Automatic film processor
	E. Attitude of platform prior to impact	1. Determination of design criteria for inclined impacts.		x				x			Motion pictures at impact may also be used.	Numerical values (inclination relative to two axes)	Automatic film processor

(A) Static Drop (B) Flight Test (1) High-Speed Motion Pictures (2) Ground-Station Recording (3) Cinetheodolite
(4) Self-Recording (5) On-Board Recording

TABLE 3–10. DATA ACQUISITION AND PROCESSING SUMMARY (Cont)

TEST PHASE	TEST DATA	POSSIBLE DATA APPLICATION	TEST METHOD (A)	TEST METHOD (B)	TEST METHOD OTHER	INSTRUMENTATION (A) (1)	INSTRUMENTATION (A) (2)	INSTRUMENTATION (B) (3)	INSTRUMENTATION (B) (4)	INSTRUMENTATION (B) (5)	REMARKS	DESIRED DATA PRESENTATION	RECOMMENDED DATA PROCESSING METHOD
RECOVERY (Cont)	F. Rotational velocity due to oscillation prior to impact	1. Determination of design criteria for drifting impacts.		x				x	x		Motion pictures at impact may also be used.	Numerical vector value	Automatic film processor
	G. Oscillation prior to impact	1. Determination of parachute stability singly and in clusters.		x				x	x		Motion pictures at impact may also be used.	Oscillation angle vs altitude	Automatic film processor Automatic record reader
	H. Forces in parachute suspension lines	1. Determination of design criteria for suspension lines, hardware, etc.		x					x	x		Numerical values (maximum force)	Manual calculation
	I. Parachute drag force	1. Determination of parachute performance due to such effects as clustering, presence of body wake, etc.		x					x	x		Numerical values (snatch, opening shock, and drag)	Manual calculation
		2. Determination of snatch force and opening shock characteristics.		x					x	x			
	J. Parachute canopy opening time	1. Determination of data for use in point of release calculations.		x				x			Also motion pictures.	Numerical values	Automatic film processor
		2. Determination of parachute characteristics.											
	K. Forces in parachute lines	1. Determination of parachute deployment and opening performance.		x					x	x		Numerical values (critical loads)	Manual calculation
	L. Horizontal displacement of rigged load	1. Determination of data for use in point of release calculations.		x				x				Plot of displacement vs altitude	Automatic film processor

(A) Static Drop (B) Flight Test (1) High-speed Motion Pictures (2) Ground-Station Recording (3) Cinetheodolite
(4) Self-Recording (5) On-Board Recording

TABLE 3-10. DATA ACQUISITION AND PROCESSING SUMMARY (Cont)

TEST PHASE	TEST DATA	POSSIBLE DATA APPLICATION	TEST METHOD (A)	TEST METHOD (B)	TEST METHOD OTHER	INSTRUMENTATION (A) (1)	INSTRUMENTATION (A) (2)	INSTRUMENTATION (B) (3)	INSTRUMENTATION (B) (4)	INSTRUMENTATION (B) (5)	REMARKS	DESIRED DATA PRESENTATION	RECOMMENDED DATA PROCESSING METHOD
IV. IMPACT	A. Impact accelerations at selected points on load	1. Determination of adequacy of energy dissipater design.	x	x		x	x		x	x	Static drop data better	Numerical values (average and peak acceleration)	Manual calculation
	B. Impact strains at selected points on load	1. Determination of inherent weaknesses of load.	x	x		x	x			x	Static drop data better	Numerical values (maximum strain)	Manual calculation
	C. Loads in suspension lines	1. Determination of parachute disconnect design criteria.		x					x	x		Plot of force vs time	Automatic record reader
	D. Loads in lashings during rebound	1. Determination of rigging design and application criteria.	x	x					x	x	Static drop data better	Numerical value: (maximum load)	Manual calculation
V. DROP ZONE OPERATIONS	A. Inspection of test items	1. Determination of final conditions of test.	x	x							Measurement of reference dimensions and still photos required.	Tabulated value: photos	Manual calculation
	B. Operation of test items	1. Determination of final conditions of test.	x	x							Field operation of test items.	Tabulated remarks, photos	Direct read-out
	C. Procedures used to recover test items	1. Determination of effectiveness of special procedures and equipment to ease ground recovery operations.		x							Still photos and motion pictures required.	Tabulated remarks, photos	Direct read-out

(A) Static Drop (B) Flight Test (1) High-Speed Motion Pictures (2) Ground-Station Recording (3) Cinetheodolite (4) Self-Recording (5) On-Board Recording

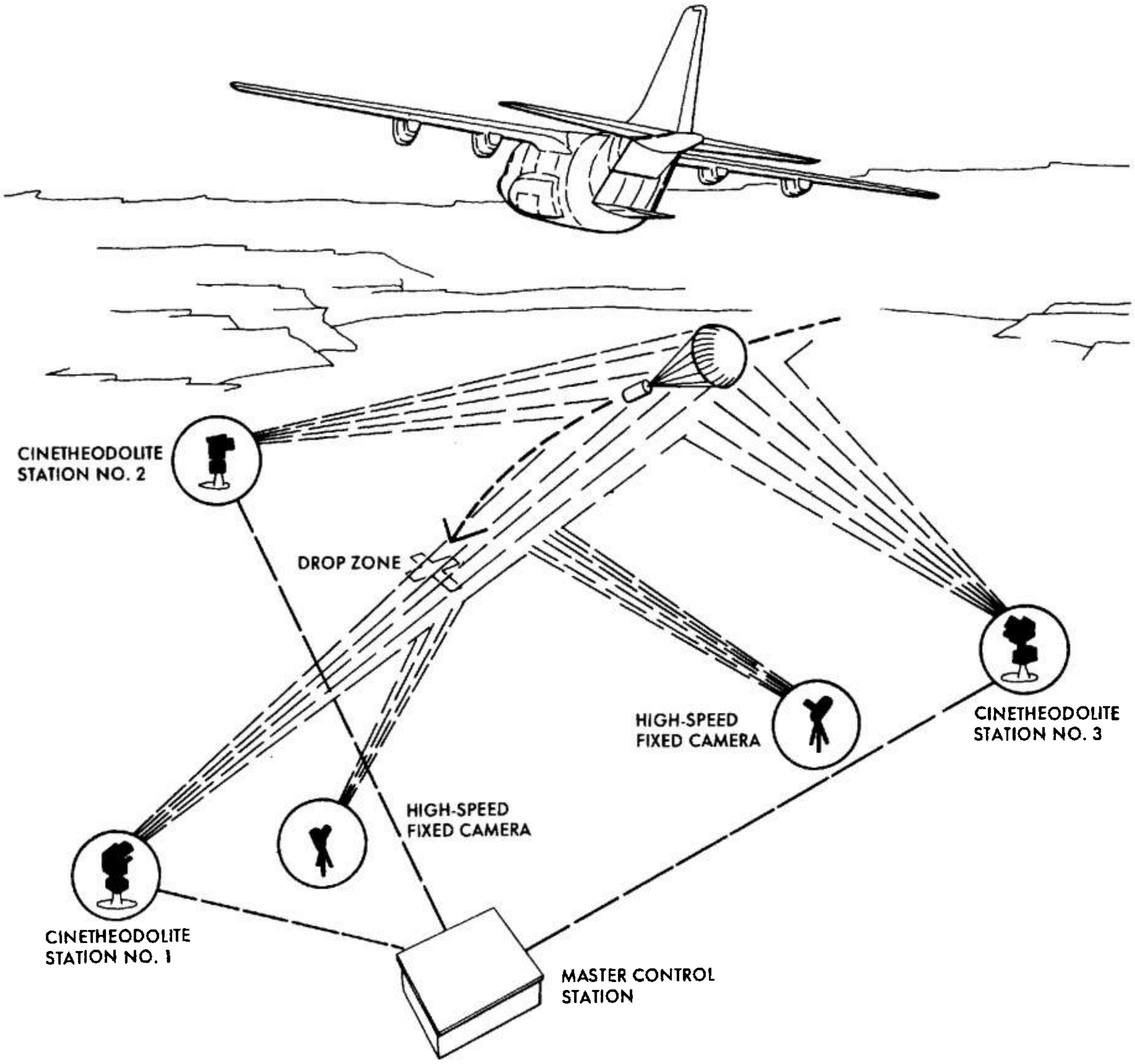


FIGURE 3-109. CINETHEODOLITE TRACKING RANGE

CHAPTER 4

AIRCRAFT CONFIGURATIONS

SECTION I

C46

4-1 GENERAL DESCRIPTION

The C-46 is a low-midwing, all-metal, twin-engine transport (Fig. 4-1). It is used primarily as a troop or cargo carrier, but can be used for medical evacuation and parachutist operations.

4-2 CARGO COMPARTMENT

The C-46 has three separate cargo compartments: main, lower forward, and lower aft (Fig. 4-2). The main cargo compartment extends from station 128 to station 704 and has a floor area of 417.2 square feet with a volume of 2572.6 cubic feet. The lower forward cargo compartment extends from station 128 to station 276 and has a floor area of 41.5 square feet, with a volume of 157.7 cubic feet. The lower aft cargo compartment extends from station 408 to station 542.5 and has a floor area of 102.6 square feet, with a volume of 253.6 cubic feet. Screens are installed in the lower cargo compartments to prevent cargo from fouling the controls.

4-2.1 FLOOR LOADING. The standard floor is a plywood floor which is replaced with a

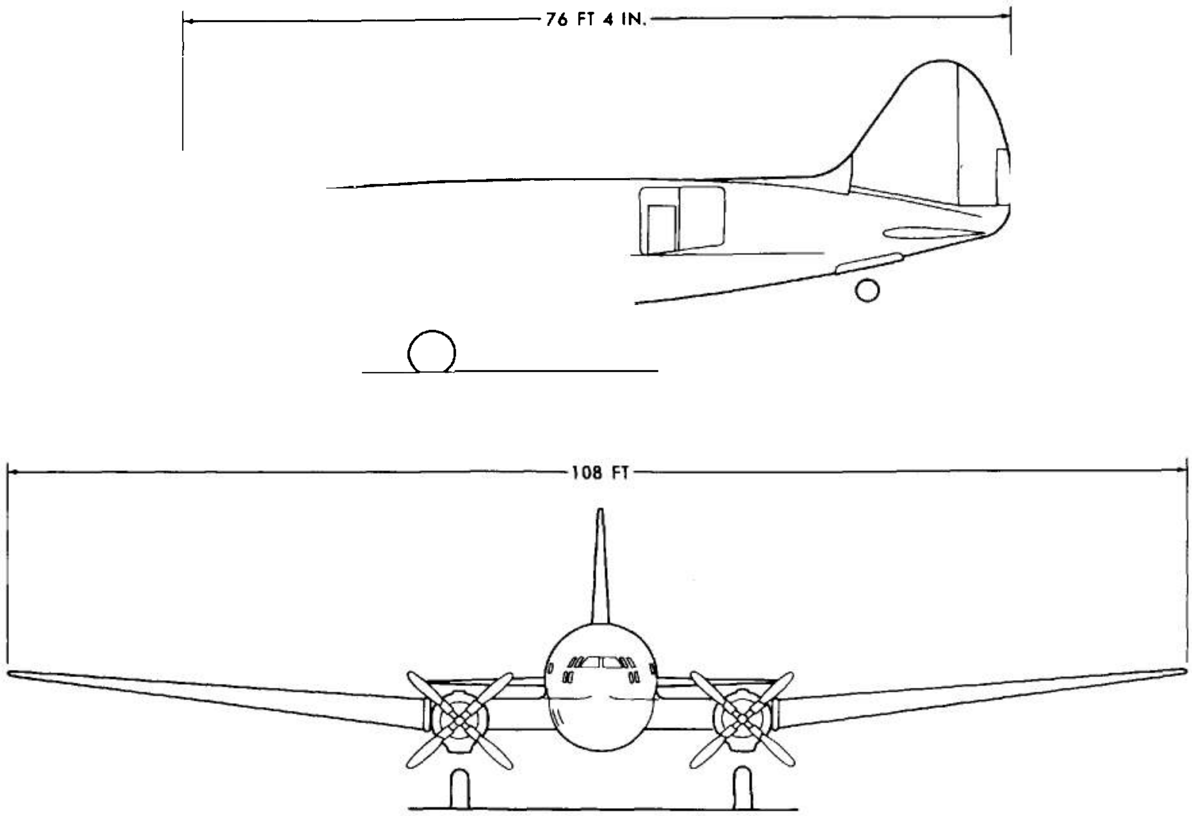


FIGURE 4-1. C-46 AIRCRAFT

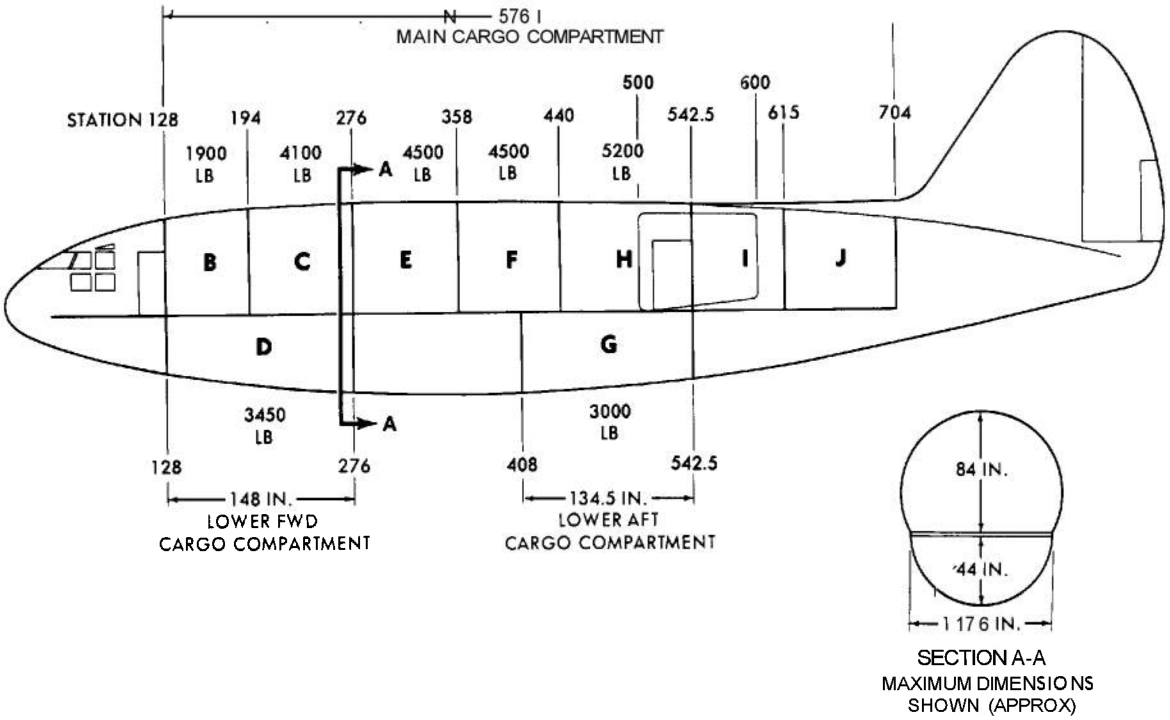


FIGURE 4–2. CARGO COMPARTMENT WEIGHT LIMITS AND DIMENSIONS, C-46 AIRCRAFT

heavier wooden floor, 1-1/2 inches thick, when vehicles or heavy cargo is to be loaded. The forward sections of the heavy wooden floor are covered with an abrasive material to prevent slippage. The three aft sections are covered with metal skid plates to assist in loading vehicles or heavy pieces of cargo. On aircraft serial No. AF 44-77444 and subsequent, the heavy wooden floor is a permanent installation. The main cargo floor maximum concentrated load is 185 pounds per square foot. The maximum concentrated load of the lower forward and aft cargo floors is 350 pounds per square foot. Individual cargo compartment maximum weight limits are shown in Fig. 4–2.

4–2.2 ANCHORING ARRANGEMENT. Four types of tiedown fittings are provided for use in securing all types of cargo. There are 23 of these fittings, threaded for attachment to fittings installed in the main cargo floor.

4–3 CARGODOORS

4–3.1 MAIN CARGO DOOR. The main cargo door is located aft of station 500 on the left side of the fuselage and opens out and upward. Dimensions of the main cargo door are shown in Fig. 4–3. The maximum size cargo package that can be loaded through the main cargo door opening may be determined graphically from Fig. A.

4–3.2 LOWER FORWARD AND AFT CARGO DOORS. The lower forward and aft cargo doors are located on the lower right side of the fuselage. Both doors are 32 inches high and 41 inches long.

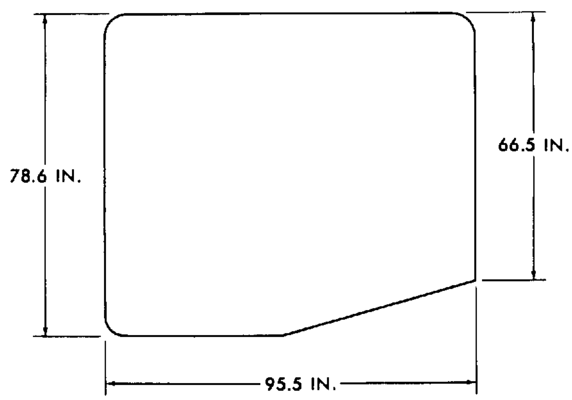


FIGURE 4–3. MAIN CARGO DOOR DIMENSIONS, C-46 AIRCRAFT

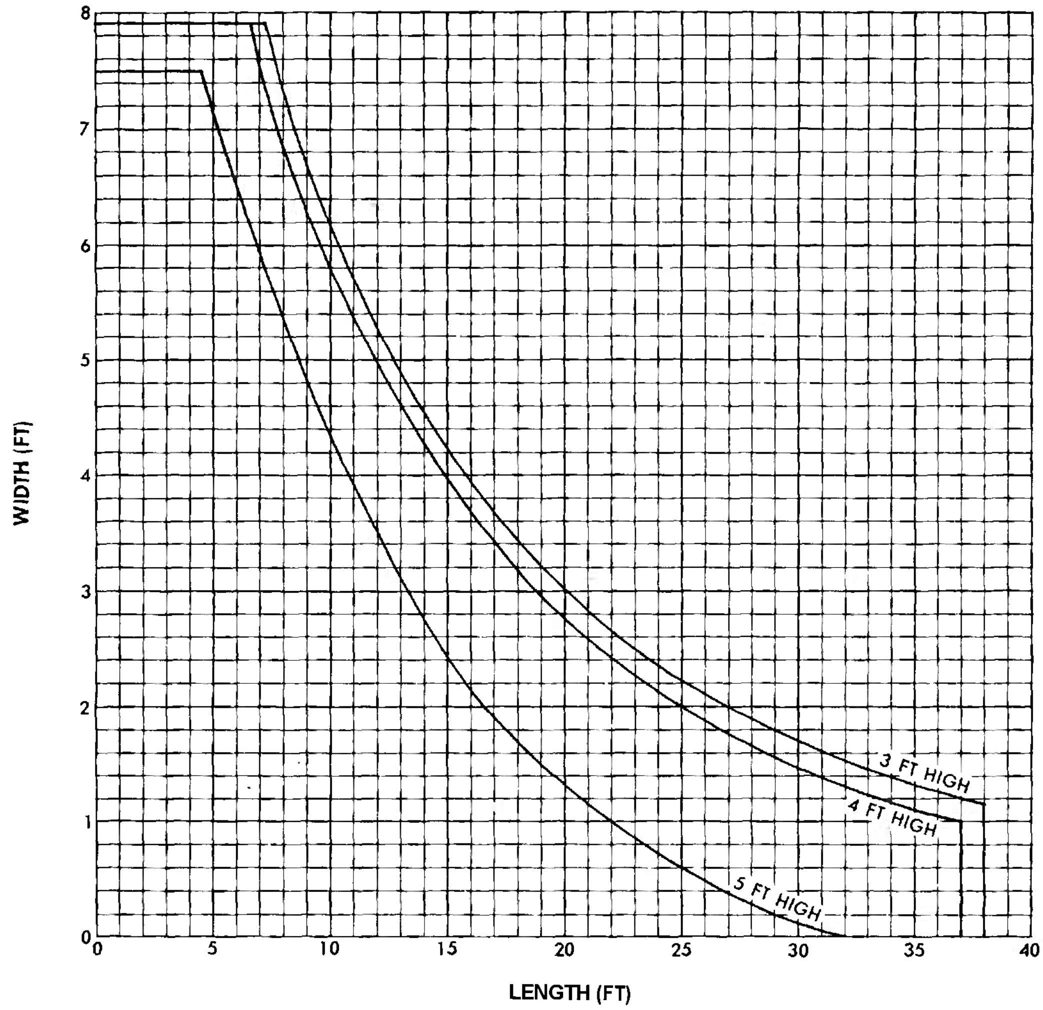


FIGURE 4-4. MAIN CARGO DOOR PACKAGE SIZE GRAPH, C-46 AIRCRAFT

4-4 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-46 aircraft:

Forward	8.0
Aft	1.5
Side	1.5
Vertical	2.0

4-5 CARGO LOADING AND UNLOADING PROVISIONS

4-5.1 LOADING PLATFORM. A loading platform can be installed on the sill of the main cargo doorway. It is used when loading 1/4-ton trucks, guns, motorcycles, or other similar types of cargo which present a problem of turning as it is being loaded. The use of this platform also permits loading ramps to be installed at an angle, since the platform is triangular in shape.

4-5.2 RAMP ATTACHMENT PLATES. The ramp attachment plates are used when the loading ramps are installed without the loading platform. The ramp attachment plates are attached to the edge of the main cargo compartment floor in the main cargo doorway. The ramp attachment plates contain the hooks to which the ends of the loading ramps are attached.

4-5.3 LOADING RAMPS. The loading ramps are used to load 1/4-ton trucks, guns, and other types of wheeled cargo directly into the main cargo compartment. The loading ramps are approximately 20 feet long and are constructed of wood. Each loading ramp weighs approximately 200 pounds, and is hinged in the middle to permit easier handling and stowage. The ends of the loading ramps are hooked to the ramp attachment plates or to the outer edge of the loading platform. The loading ramps can be placed together or be placed as far as 5 feet apart to meet various loading conditions.

4—5.4 SCUFF FRAME. The scuff frame is installed on the main cargo door frame to protect it when loading a vehicle or large pieces of cargo. The scuff frame is constructed of wood and molded to fit the contour of the main cargo door frame.

4—5.5 HYDRAULIC WINCH. The hydraulic winch is installed on a permanent base at the forward end of the main cargo compartment, just inboard of the navigator's seat, at station 168.79. It is used to winch heavy cargo up the loading ramps. The hydraulic winch is actuated by operating the right-hand engine at about 1500 rpm to produce hydraulic pressure for the winch. A snatch block, idler pulley, and winching cable are used in conjunction with the hydraulic winch to winch heavy cargo into the main cargo compartment. The winching cable is threaded through the idler pulley, which is attached to a fitting on the cargo floor centerline at station 295.906, and through the snatch block attached to the bulkhead at station 501.5. The end of the winching cable is attached to the cargo being loaded. After the cargo is winched onto the loading platform, the snatch block at station 501.5 is moved and attached to a fitting on the bulkhead at station 378.5, to give a more direct pull into the main cargo compartment.

SECTION II

C-47

4—6 GENERAL DESCRIPTION

The C-47 is a twin-engine, low-wing monoplane equipped with a retractable main landing gear (Fig. **4—5).** It is designed to be used as a cargo, ambulance, or troop transport, capable of carrying up to 28 troops or up to 24 litters.

4—7 CARGO COMPARTMENT

The cargo compartment extends from station 177.5 to station 538.0, a length of **360.5** inches (Fig. **4—6).** The cargo compartment has a maximum height of 76.8 inches, a maximum width of 88.8 inches at floor level, and a floor area of 213 square feet. The total volume is 1227 cubic feet. Total capacity for each compartment is shown in Fig. 4—7.

4—7.1 **FLOOR LOADING.** Distributed and concentrated load limits are listed in Table 4—1. To compute floor loads, use only the area actually in contact with the floor. In addition to the load indicated in column 5 of Table 4—1, the remainder of the compartment may be loaded to the value shown in column **4,** provided the compartment capacity is not exceeded. Column 6 refers to concentrated loads produced by the wheels of vehicles. Such loads must be located directly over floor beams and are subject to the following limitations:

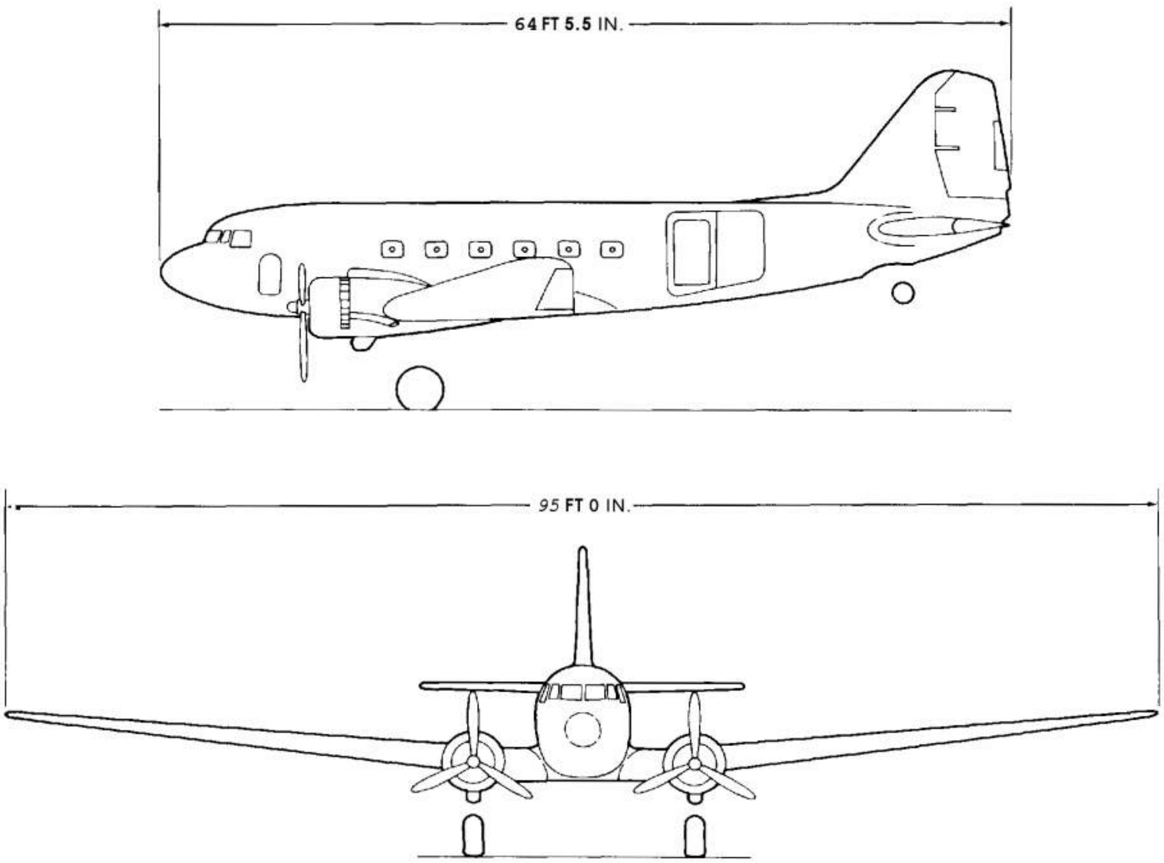


FIGURE 4-5. C-47 AIRCRAFT

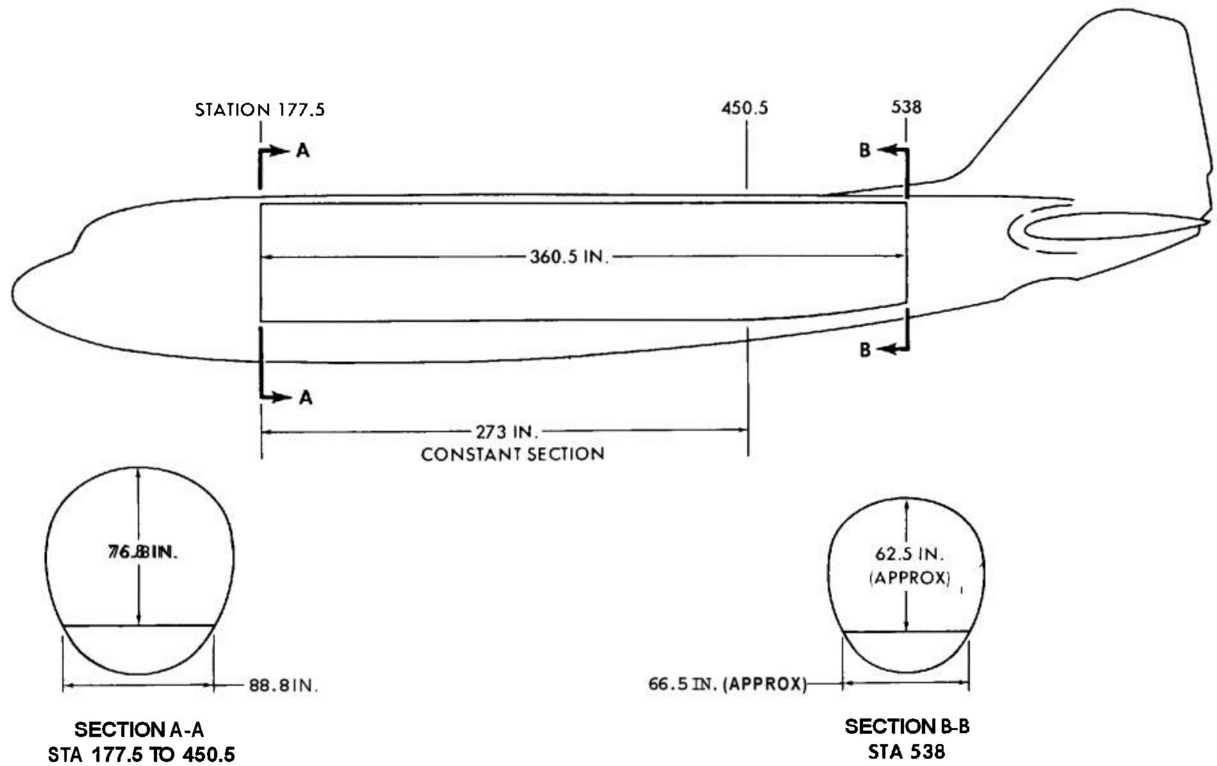


FIGURE 4-4 CARGO COMPARTMENT DIMENSIONS, C-47 AIRCRAFT

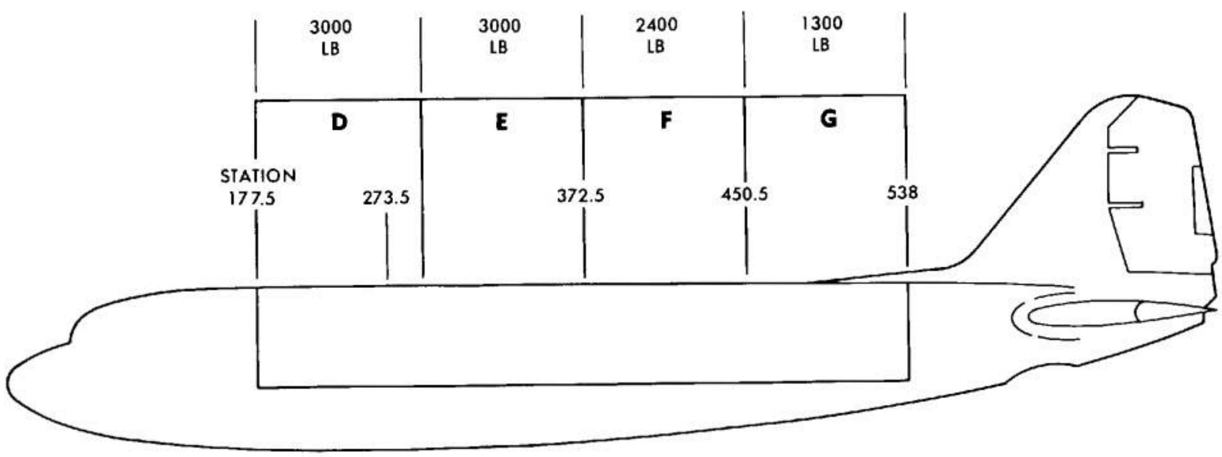


FIGURE 4-7. CARGO COMPARTMENT WEIGHT LIMITS, C-47 AIRCRAFT

TABLE 4-1. CARGO COMPARTMENT CAPACITIES, C-47 AIRCRAFT

1			4	5	6
COMPARTMENT	COMPARTMENT CAPACITY (lb)	AREA (ft^2)	MAXIMUM LOAD EVENLY DISTRIBUTED OVER ENTIRE COMPARTMENT (lb/ft^2)	MAXIMUM LOAD EVENLY DISTRIBUTED OVER LIMITED AREA (5 FT^2 IN ANY ONE COMPARTMENT) (lb/ft^2)	MAXIMUM CONCENTRATED LOAD FOR LIMITED AREA ($lb/in.^2$)
D	3000	59.9	50	125	66
E	3000	59.3	50	125	66
F	2400	47.7	50	125	66
G	1300	45.0	50	125	66

a. Smooth floor over beams marked A in Fig. 4—8, *66* pounds per square inch over a maximum area of 12 square inches.

b. Smooth floor over beams not marked A, *66* pounds per square inch over a maximum area of *6* square inches.

c. Corrugated floor (bare) over any beam, 20 pounds per square inch over a maximum area of 25 square inches.

d. Corrugated floor (covered with 3/4- by 22-inch plywood) over beams marked A, *66* pounds per square inch over a maximum area of 25 square inches.

e. Corrugated floor (covered with 3/4- by 22-inch plywood) over beams not marked A, *66* pounds per square inch over a maximum area of 12 square inches.

4—7.2 ANCHORING ARRANGEMENT. See Fig. 4-8 for anchoring arrangement and fitting capacities.

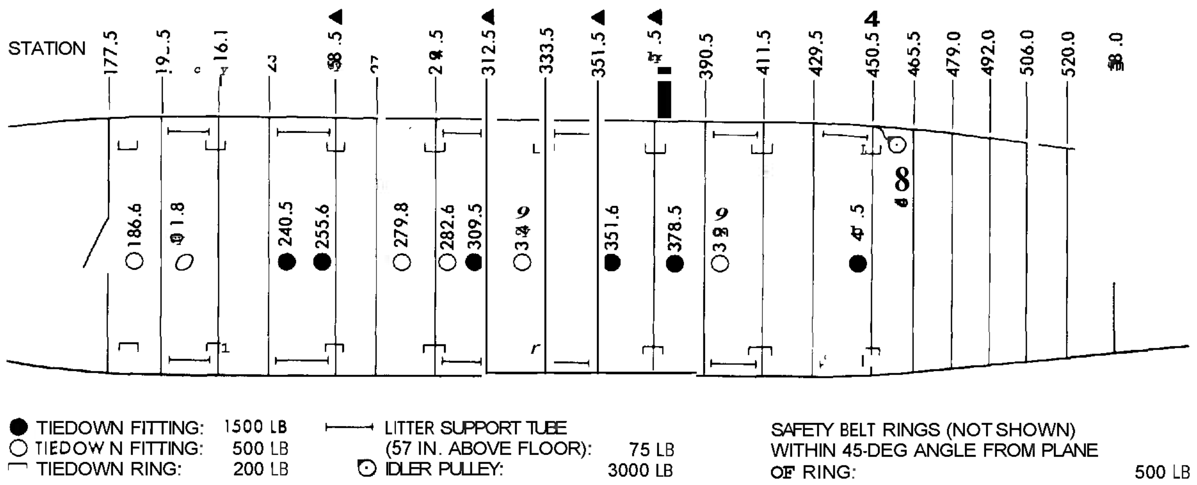


FIGURE 4-8. ANCHORING ARRANGEMENT, C-47 AIRCRAFT

48 CARGODOORS

Double cargo doors, divided in the center, are located on the left side of the aircraft, aft of the wing. The doors are mounted on hinges that swing outward. They may be secured against the side of the fuselage in the open position or removed to permit unobstructed cargo loading. The forward cargo door incorporates a smaller door that may be used as a paratroop exit. Dimensions of the cargo doors are shown in Fig. 4–9. Maximum package size for cargo doors can be determined from Table 4–2 as follows:

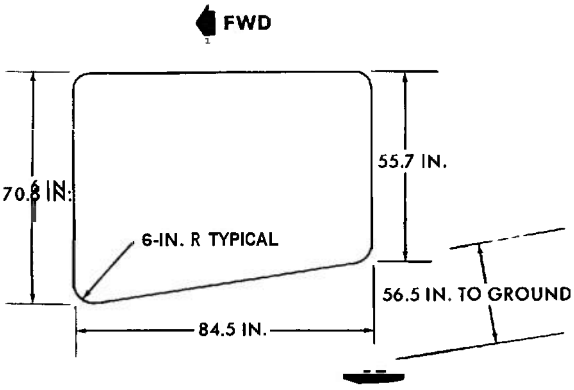


FIGURE 4–9. CARGO DOOR DIMENSIONS, C-47 AIRCRAFT

TABLE 4-2. MAXIMUM PACKAGE SIZE, C-47 AIRCRAFT

	WIDTH (IN.)													
LENGTH (IN.)	4	8	12	16	20	24	28	32	36	40	44	48	52	56
69	69	69	69	69	69	69	69	69	69	69	69	69	69	68
73	73	73	73	73	73	73	73	73	73	73	73	73	73	60
77	77	77	77	77	77	77	77	77	77	77	76	76	76	60
81	81	81	81	81	80	80	80	80	80	80	72	72	72	60
85	85	84	84	80	76	76	72	72	72	72	68	64	64	60
89	84	84	80	80	76	72	72	68	68	64	64	64	60	56
93	84	84	80	80	76	72	68	68	64	64	64	64	60	56
97	84	84	80	76	72	72	68	64	64	64	64	60	60	56
101	84	80	76	76	72	68	64	64	64	64	64	60	60	
105	80	80	76	76	72	68	64	64	64	64	60	60	60	
109	80	80	76	72	68	68	64	60	60	56	56	56	56	
113	76	76	76	72	68	64	60	60	60	56	56	56	52	
117	76	76	76	72	68	64	60	60	60	56	56	56	52	
121	76	76	72	68	64	60	60	60	56	56	56	52		
125	76	76	72	68	64	60	60	56	56	56	56	52		
129	76	76	72	68	64	60	60	56	56	56	56	52		
133	72	72	68	68	64	60	60	56	56	56	52	48		
137	72	72	68	64	64	60	60	56	56	56	52			
141	72	72	68	64	64	60	60	56	56	56	52			
145	72	72	68	64	64	60	60	56	56	52	52			
149	72	72	68	64	64	60	60	56	56	52	48			
153	72	72	68	64	64	60	60	56	56	52	48			
157	72	72	68	64	60	60	56	56	52	52	48*			

*Seat beam must be removed from right hand side between stations 372.5 and 450.5.

TABLE 4–2. MAXIMUM PACKAGE SIZE, C-47 AIRCRAFT (Cont)

LENGTH (IN.)	WIDTH (IN.) 4	8	12	16	20	24	28	32	36	40	44	48	52	56
161	72	72	68	64	60	60	56	56	52	48	44*			
165	72	68	68	64	60	60	56	56	52	48				
169	72	68	68	64	60	60	56	56	52	48*				
173	72	68	68	64	60	60	56	56	52	44*				
177	72	68	68	64	60	60	56	56	52	40*				
181	72	68	64	64	60	60	56	52	48					
185	72	68	64	64	60	60	56	52	48					
189	72	68	64	64	60	60	56	52	48					
193	68	68	64	64	60	60	56	52	44					
197	68	68	64	64	60	60	56	52	44					
201	68	68	64	64	60	60	56	48	36					
205	68	68	64	64	60	60	56	48						
209	68	68	64	64	60	60	56	48						
213	68	68	64	64	60	60	56	48						
217	68	68	64	60	60	56	56	48						
221	68	68	64	60	60	56	52	44						
225	68	68	64	60	60	56	52	44						
229	68	68	64	60	60	56	52	44						
233	68	68	64	60	60	56	52	40						
237	68	68	64	60	60	56	52	36						
241	68	64	64	60	60	56	48	36						
245	68	64	64	60	60	56	48	32						
249	68	64	64	60	60	56	48	32						
253	68	64	64	60	60	56	48							
257	68	64	64	60	56	52	44							
261	68	64	64	60	56	52	44							
265	68	64	64	60	56	52	44							
269	68	64	64	60	56	52	40							
273	68	64	64	60	56	52	40							
277	68	64	64	60	56	52	32							
281	68	64	64	60	52	52	28							
285	68	64	64	60	52	52	28							
289	68	64	64	60	52	48	28							

+Seat beam must be removed from right hand side between stations 372.5 and 450.5.

TABLE 4–2. MAXIMUM PACKAGE SIZE, C-47 AIRCRAFT (Cont)

LENGTH (IN.)	WIDTH (IN.) 4	8	12	16	20	24	28	32	36	40	44	48	52	56
293	68	64	64	60	52	48								
297	68	64	64	60	52	48								
301	68	64	60	60	52	48								
305	68	64	60	60	52	48								
309	68	64	60	60	52	44								
313	68	64	60	60	52	40								
317	68	64	60	60	52	40								
321	68	64	60	60	52	40								
325	68	64	60	60	52	40								
329	68	64	60	56	52	36								
333	68	64	60	56	52	36								
337	68	64	60	56	52	32								
341	68	64	60	56	52	32								
345	68	64	60	56	52	32								
349	68	64	60	56	52	28								
353	64	64	60	56	48	28								
357	64	60	56	52	48	24								
362	48	44	40											
366	8													

a. In the length column, find the longest dimension of the package. If the exact dimension is not shown, use the next larger dimension.

b. In the width column, find the shortest dimension of the package. If the exact dimension is not shown, use the next larger dimension.

c. At the intersection of the length and width dimensions in the body of the table, find the maximum height. If the height of the package is the same or less than this dimension, the package can be loaded. Height dimensions marked with an asterisk (*) indicate seat beam must be removed from righthand side between stations 372.5 and 450.5.

4–9 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-47 aircraft:

Forward	8.0
Aft	1.5
Side	1.5
Vertical	2.0

A 10 CARGO LOADING AND UNLOADING PROVISIONS

Loading of cargo is accomplished through the double cargo loading doors, with the snatch block and idler pulley, a small and large platform, and a set of loading ramps. Holes for attachment of the loading ramps are provided in the sill of the cargo loading doors.

SECTION III

C-54

4—11 GENERAL DESCRIPTION

The C-54 is a four-engine, low-wing monoplane with a fully retractable tricycle landing gear (Fig. 4—10). It is designed as a long-range cargo, troop, or personnel transport, capable of carrying up to 49 passengers or up to 36 litters.

4—12 CARGO COMPARTMENT

The cargo compartment extends from station 260.9 to station 858.0, with a maximum width of 103.2 inches and a maximum height of 93.75 inches. Dimensions and contours of the cargo compartment are shown in Fig. 4—11. The volume of the cargo compartment, including lower compartments, is 1485 cubic feet.

A 12.1 FLOOR LOADING. The distributed load capacity for the cargo compartment is 200 pounds per square foot except for compartments J, K, and L which have a capacity of 100 pounds per square foot. The total capacity for each compartment is shown in Fig. 4–12.

4—12.2 ANCHORING ARRANGEMENT. The tie-down fittings are located on a 20-inch grid pattern and are equipped with flush-seal plugs to provide a smooth surface and to protect the threads when the fittings are not in use (Fig. 4—13). Eyebolts are installed in the fittings as required for securing cargo. Cargo carried in the lower compartments is secured with straps.

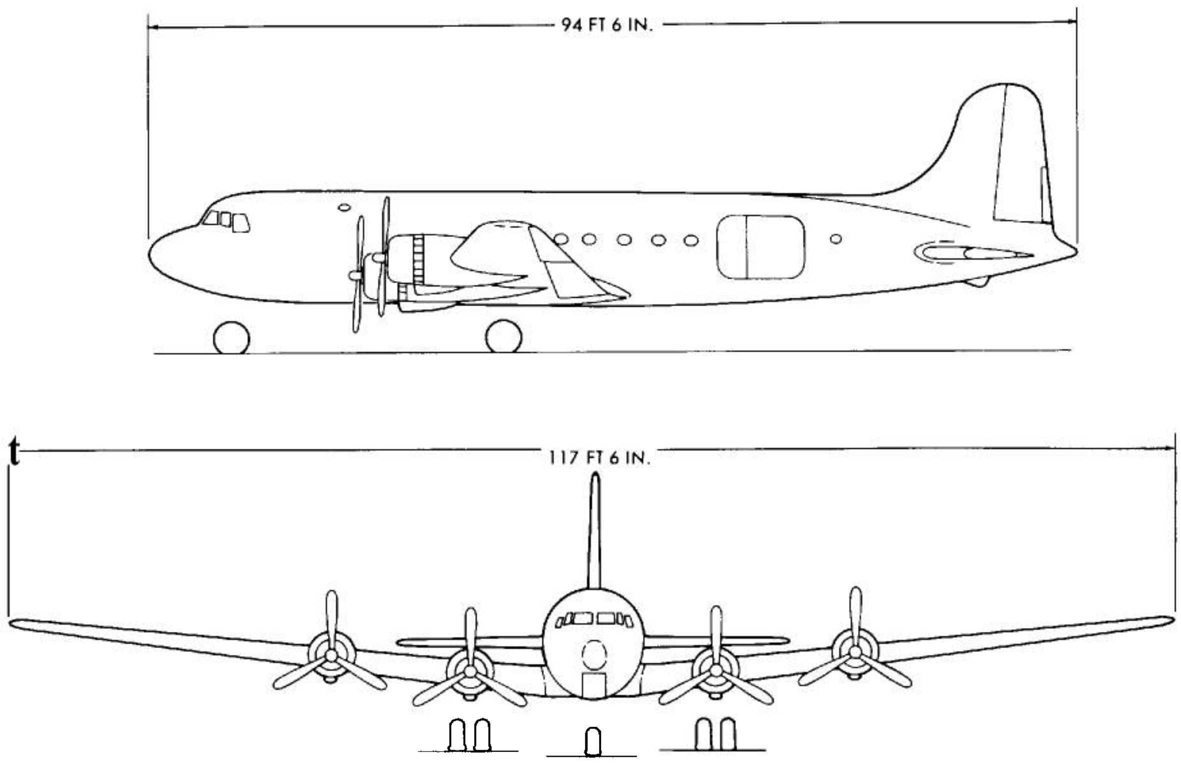


FIGURE 4–10. C-54 AIRCRAFT

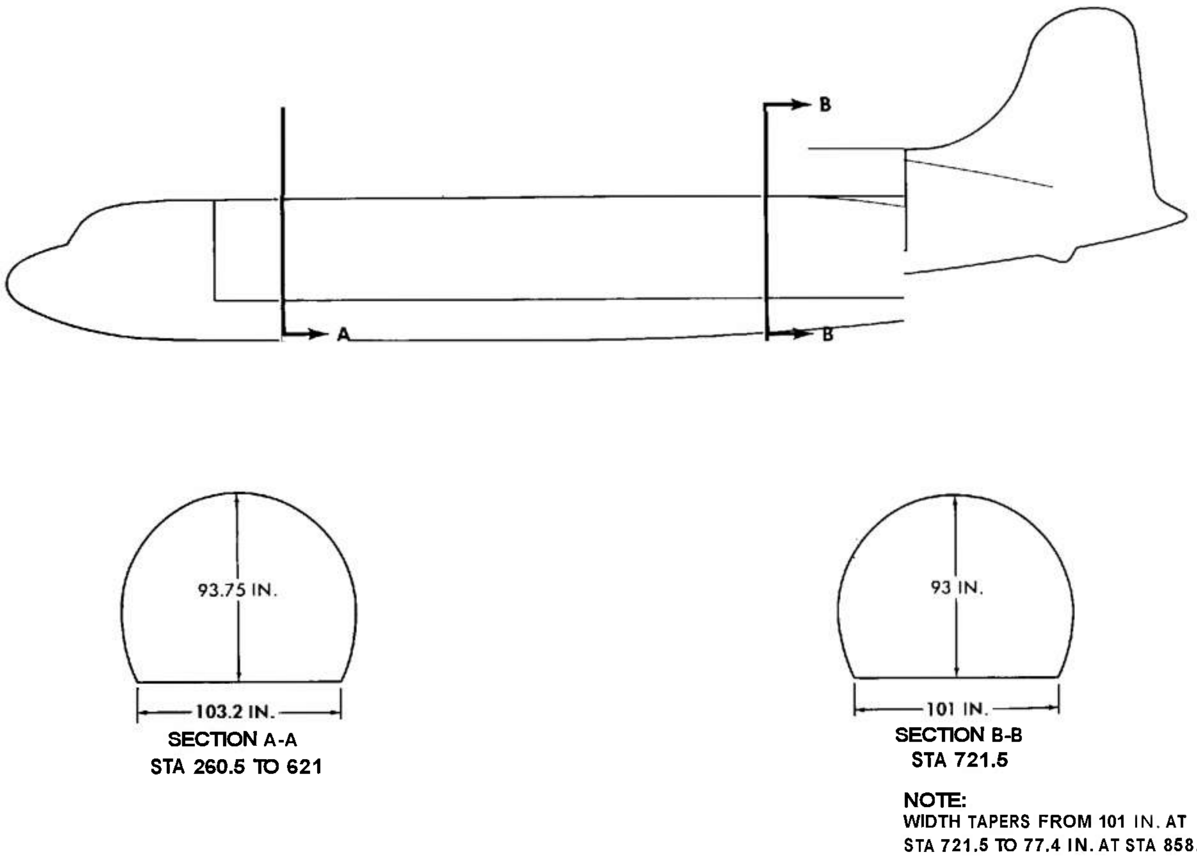


FIGURE 4-11. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-54 AIRCRAFT

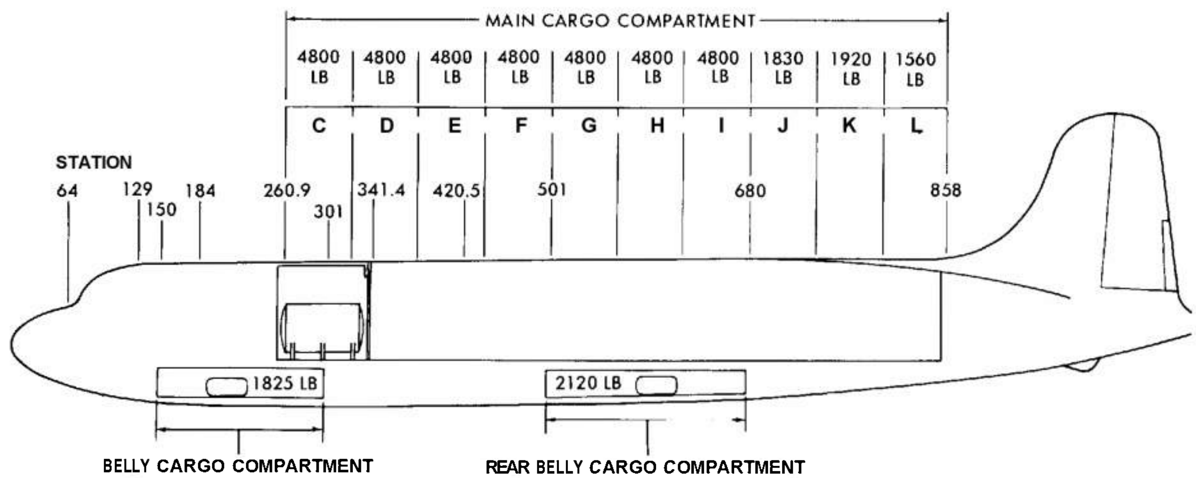


FIGURE 4-12. CARGO COMPARTMENT WEIGHT LIMITS. C-54 AIRCRAFT

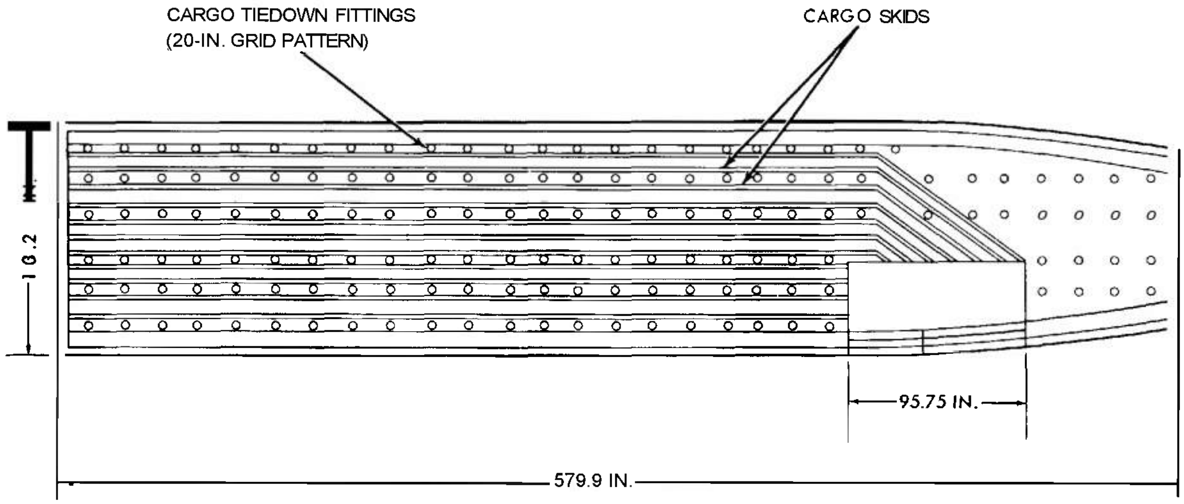


FIGURE 4–13. ANCHORING ARRANGEMENT, C-54 AIRCRAFT

4–43 CARGO DOORS

Double doors are provided on the left side of the fuselage, aft of the wing (Fig. 4—14). Hinges permit the doors to open outward, and a trigger latch mechanism is provided to secure each door to the fuselage in the open position. With both doors fully open, the cargo entrance is 95-3/4 inches wide by 67 inches high. Each corner of the entrance is rounded with an 8-1/8-inch radius. Maximum package size for loading through the cargo doors is shown in Fig. 4—15. To determine if a package not exceeding 66 inches in depth can be loaded, measure the length and width (two greatest dimensions) of the package. Select corresponding numbered lines on Fig. 4—15. If selected lines intersect within the graph area below load curve line, the package can be loaded. Cargo doors, hinged to open inward, are provided for the two lower cargo compartments.

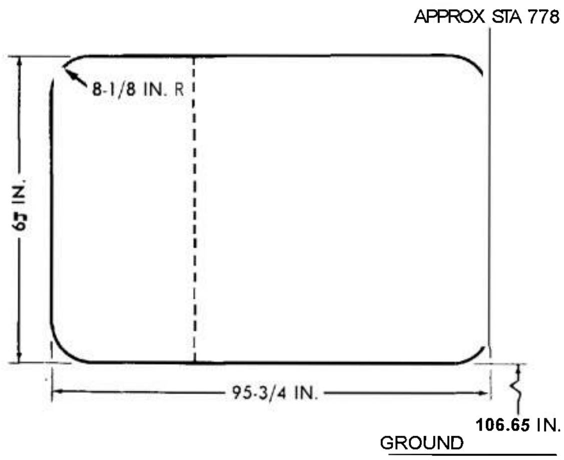


FIGURE 4–14. CARGO DOOR DIMENSIONS, C-54 AIRCRAFT

4–44 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-54 aircraft:

Forward	8.0
Aft	1.29
Side	1.00
Vertical	2.47

A 1 5 CARGO LOADING AND UNLOADING PROVISIONS

The C-54 aircraft has provisions for a boom hoist in the cargo compartment aft of the aft cargo door.

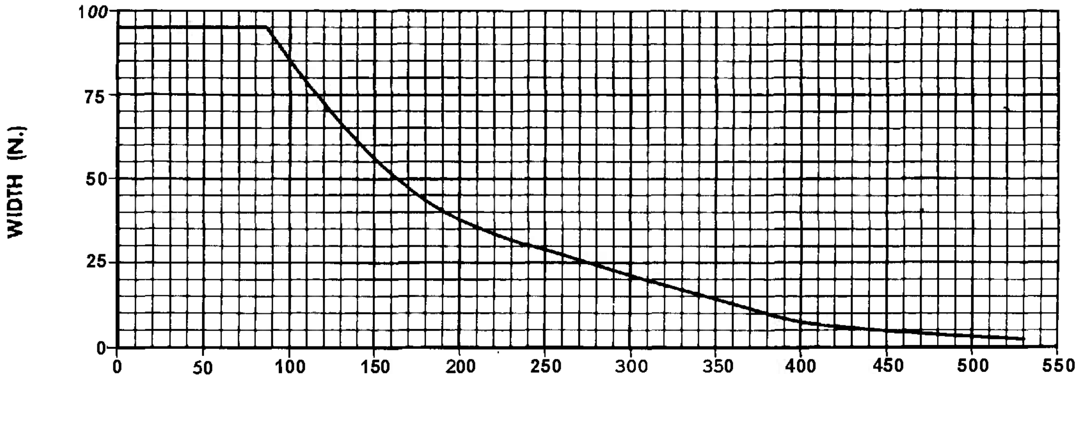


FIGURE 4-15. CARGO DOOR PACKAGE SIZE GRAPH, C-54 AIRCRAFT

SECTION IV

c-97

4—16 GENERAL DESCRIPTION

The C-97 is a four-engine, low-wing, heavy transport (Fig. 4—16). It is designed as a long-range cargo or personnel transport. There are four models of this aircraft: C-97A, C-97C, KC-97F, and KC-97G. The K denotes a tanker configuration having air refueling equipment. The air refueling equipment can be removed for transporting cargo or troops. The C-97 does not have provisions for parachutists. A monorail system is available for airdrop of cargo; however, the C-97 is not used by the Army for airdrop of cargo. The monorail system is capable of delivering **25,500** pounds over a limited area in approximately **15** seconds.

A 17 CARGO COMPARTMENT

The C-97 has three separate cargo compartments: main, lower forward, and lower *aft.* The main cargo compartment extends from station **230** to station 994 and has a floor area of 579 square feet. The lower forward cargo compartment extends from station 230 to station 483 with a floor area of 108 square feet. The lower aft cargo compartment extends from station **585** to station 790 and has a floor area of 94 square feet. Critical contour for the cargo compartments is shown in Fig. 4—17.

4—17.1 FLOOR LOADING. Flooring for the three cargo compartments is constructed of

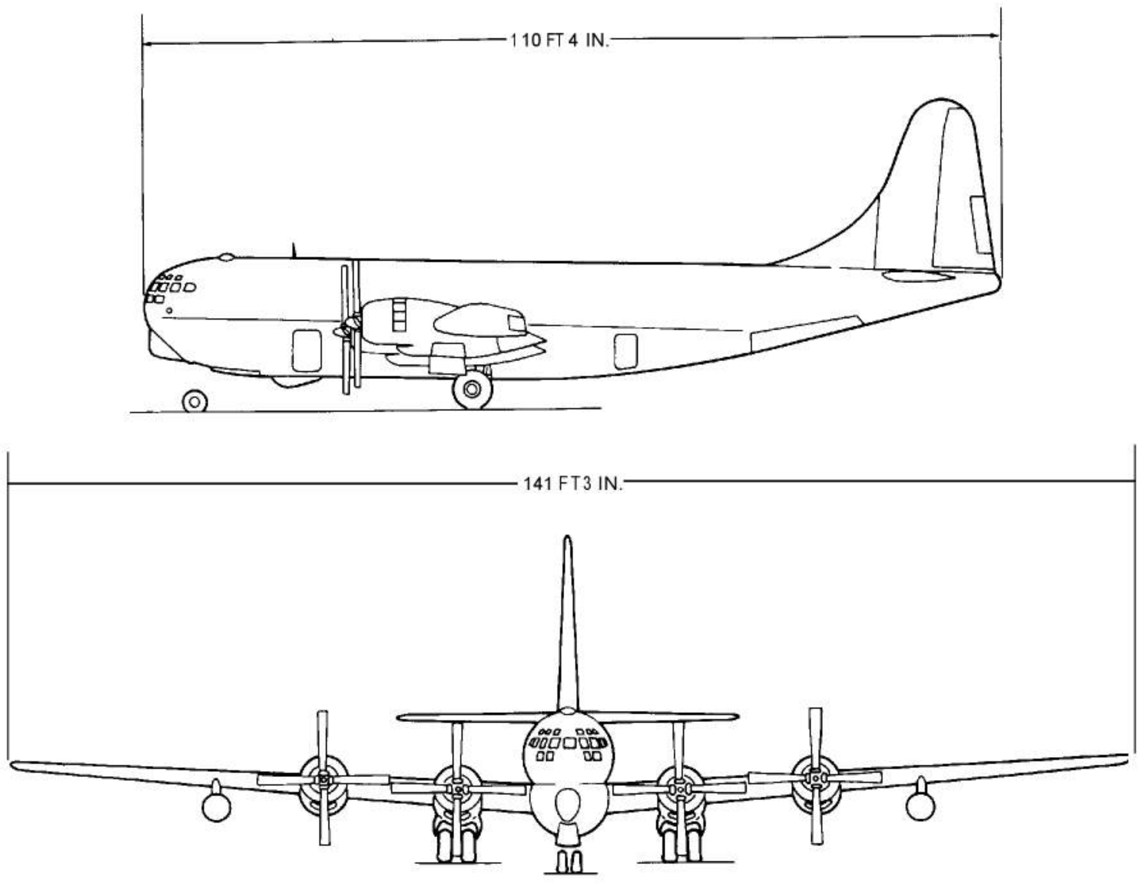
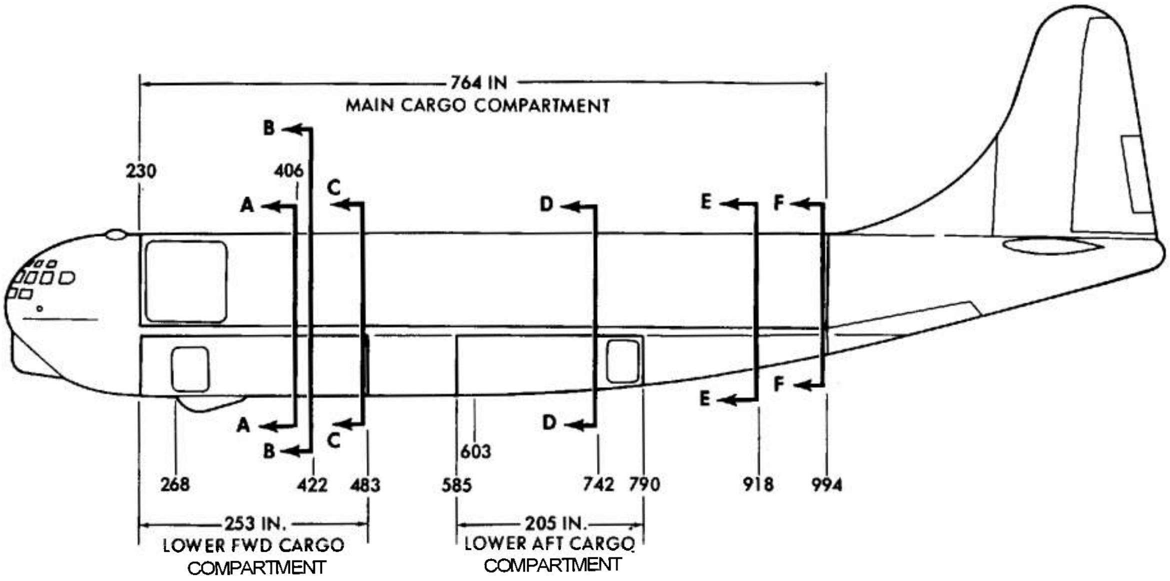
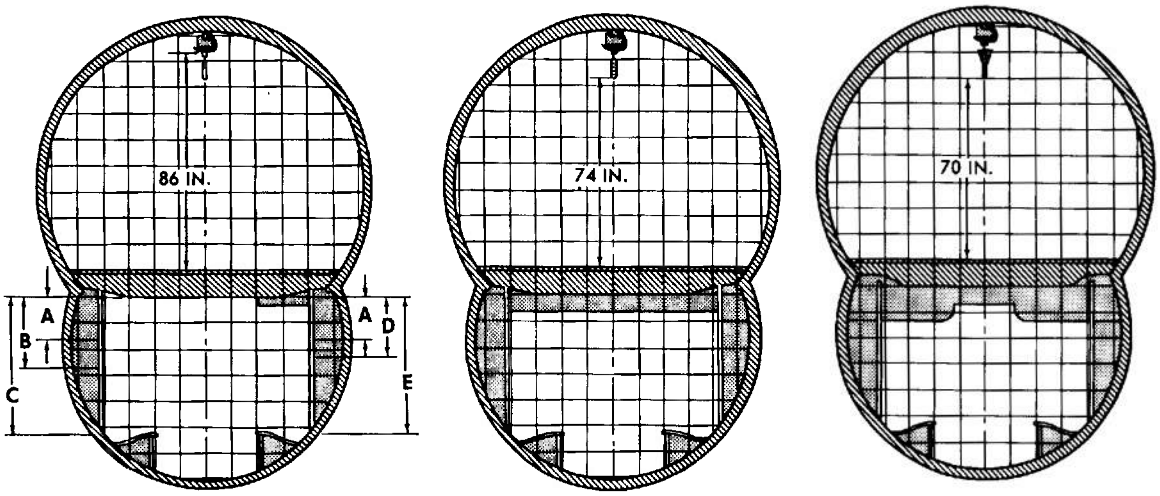


FIGURE 4-16. C-97 AIRCRAFT





SECTION A–A

STA 406 TO 230 (MAIN COMPARTMENT)
STA 406 TO 268 (LOWER FWD COMPARTMENT)

SECTION B–B

STA 422 TO 406

SECTION C–C

STA 483 TO 422

A DEPTH OF OBSTRUCTION FROM STA 268 TO 342

B DEPTH OF OBSTRUCTION AT STA 390. DEPTH INCREASES GRADUALLY FROM STA 342 TO 390

C DEPTH OF OBSTRUCTION FROM STA 390 TO 406

D DEPTH OF OBSTRUCTION AT STA 370. DEPTH INCREASES GRADUALLY FROM STA 342 TO 370

E DEPTH OF OBSTRUCTION FROM STA 370 TO 406

NOTE:
OBSTRUCTIONS IN THE CARGO COMPARTMENTS ARE REPRESENTED BY SHADED AREAS
EACH DIVISION OF THE GRID PATTERN REPRESENTS 10 INCHES.

FIGURE 4–17. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-97 AIRCRAFT (1 OF 2)

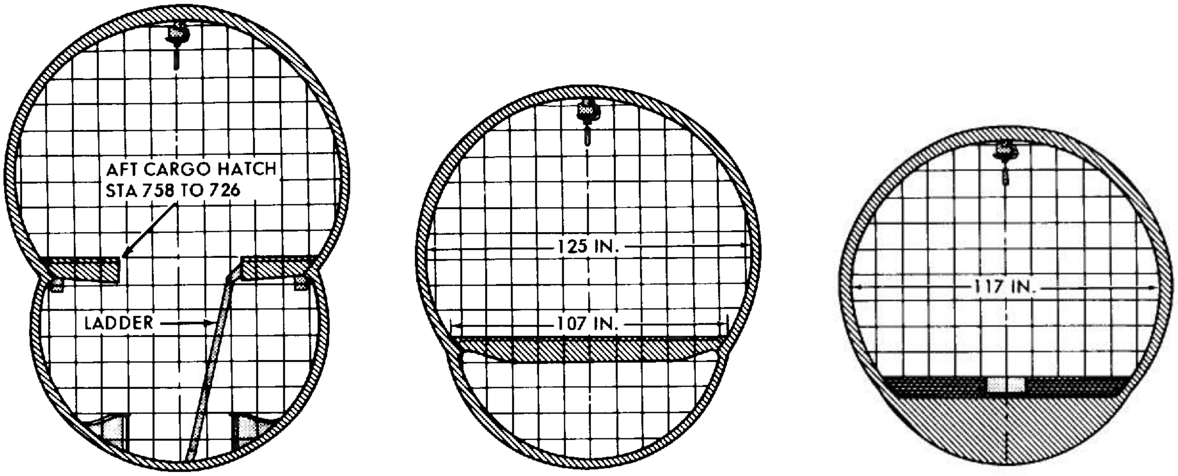


FIGURE 4–17. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-97 AIRCRAFT (2 OF 2)

aluminum alloy panels. Main cargo compartment floor panels are supported by traverse beams attached to each circumferential frame. The lower forward and aft cargo compartment floor panels are secured to the circumferential frames. The main floor will support a distributed load of ***200*** pounds per square foot. Lower forward and aft floors will support a distributed load of 100 pounds per square foot. Individual cargo compartment maximum weight limitations are shown in Fig. 4–18.

4–17.2 ANCHORING ARRANGEMENT. Cargo floor fittings for the main cargo compartment are shown in Fig. 4–19. In addition to the fittings shown in Fig. 4–19, the main cargo compartment is equipped with thirty-six 10,000-pound overhead and sidewall fittings and twelve 25,000-pound sidewall fittings. The lower forward and aft cargo compartments have three rows of 200-pound cargo floor fittings spaced on 16-inch centers. Troop seat fittings are provided in all cargo compartments.

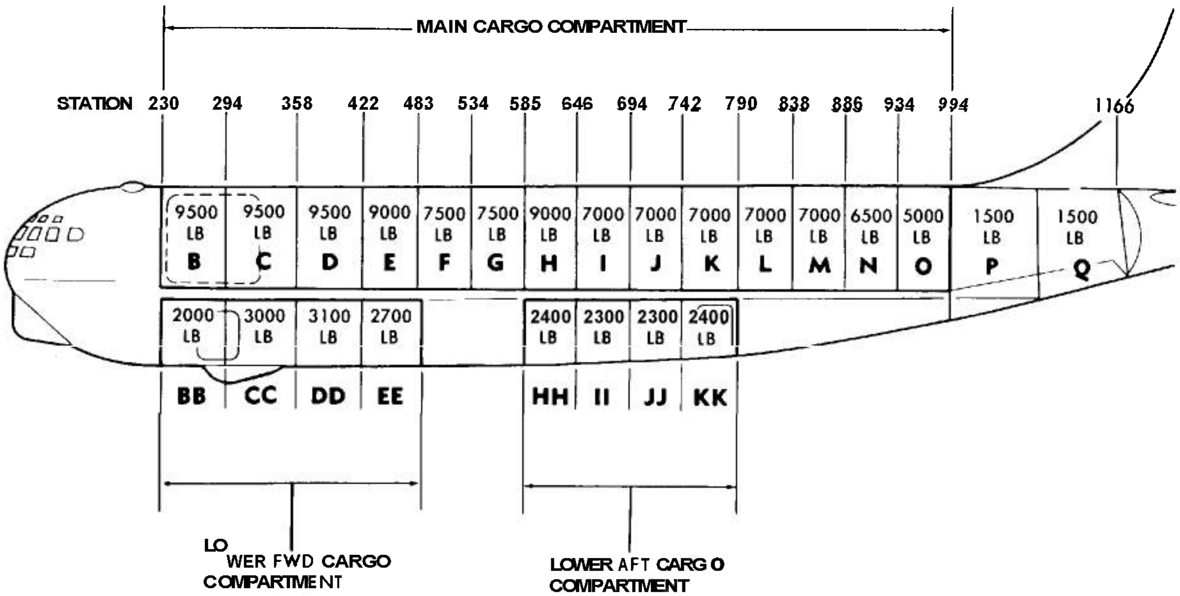
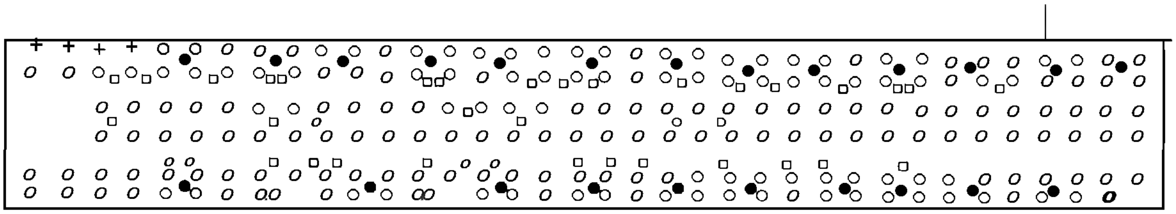


FIGURE 4–18. CARGO COMPARTMENT WEIGHT LIMITS, C-97 AIRCRAFT



+ 200 LB   ○ 1250 LB   ● 10,000 LB   □ 10,000 LB VERTICAL   6000 LB HORIZONTAL

FIGURE 4–19. ANCHORING ARRANGEMENT, C-97 AIRCRAFT

4—18 CARGO DOORS AND RAMPS

4—18.1 CARGO DOORS. The main cargo door **(Fig.** 4—20), located at the aft end of the aircraft, is flight-operable, permitting air delivery from the monorail system. The main cargo door provides an opening to the main cargo compartment 149 inches long by 72 to 103 inches wide, with a vertical clearance of 84 inches. The height, above ground, of the main cargo door, is 112 inches. Figure 4—2 1 indicates maximum package size for loading through the main cargo door. The example chase line on Fig. 4—21 indicates a package 35 inches high by 80 inches wide can be loaded, providing the length does not exceed 640 inches.

Some C-97 aircraft have a forward cargo door located on the right side between stations 246 and 326 (Fig. 4—22). Figure 4—23 indicates maximum package size for loading through the forward cargo door. The example chase line on **Fig.** 4—23 indicates a package 25 inches high by 15 inches wide can be loaded, providing the length does not exceed 360 inches.

A forward cargo hatch is located in the main cargo compartment floor above the lower forward cargo compartment. The hatch is constructed in two sections as shown in Fig. 4—24. Table 4—3 indicates maximum package size for loading through the forward cargo hatch. To use the table, find the smallest (first) dimension of the package to be loaded in the left-hand vertical column. If the exact dimension is not shown, use the next higher number. Find the next larger (second) dimension in the upper horizontal column. Proceed horizontally from the first dimension and vertically from the second dimension to find the maximum permissible third dimension.

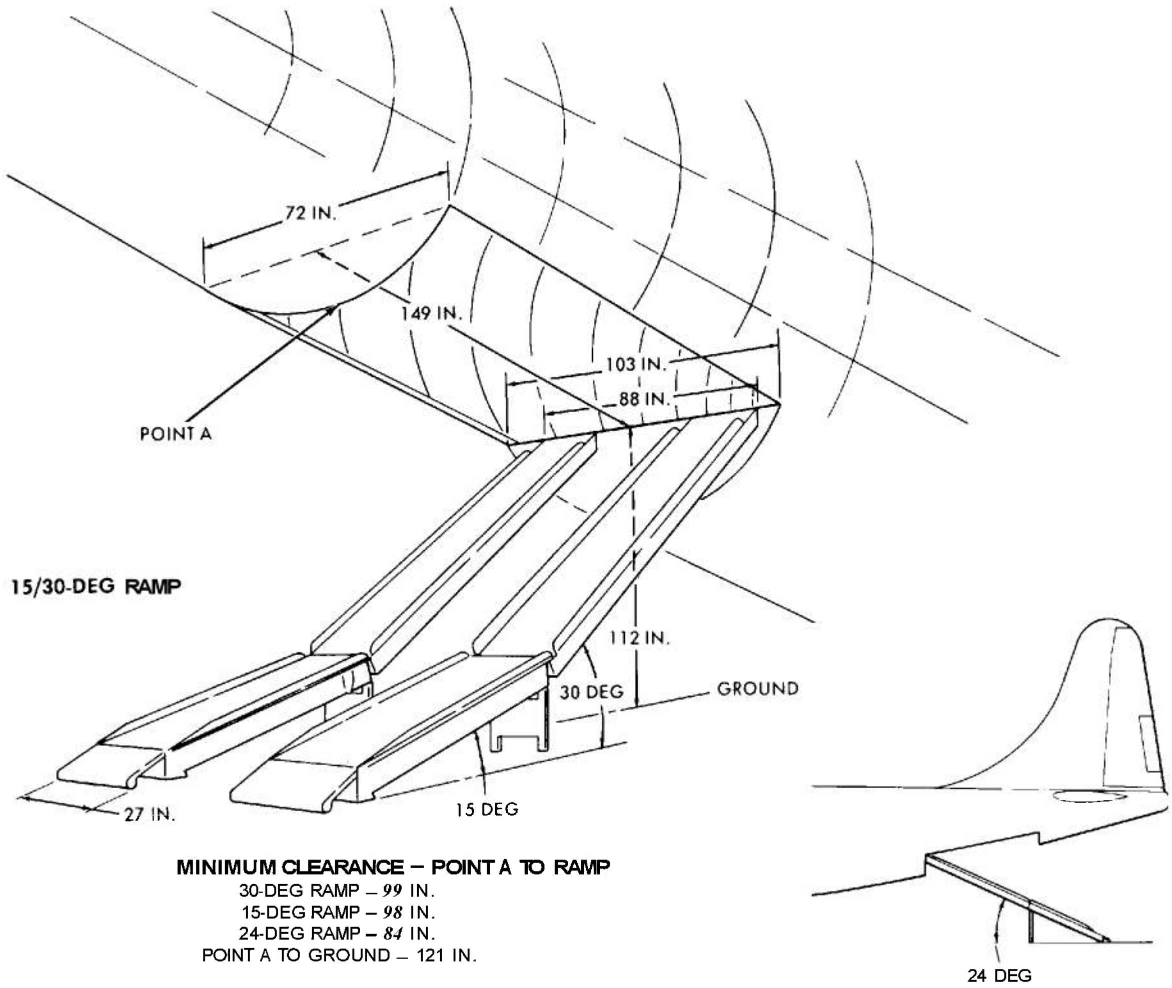
An aft cargo hatch is located in the main cargo compartment floor above the lower aft cargo compartment. Dimensions of the aft cargo hatch are shown in Fig. 4—25. Table 4—4 indicates maximum package size for loading through the aft cargo hatch. Use the method described above to find package size.

4—18.2 RAMPS. Folding ramps are included on the aircraft to be used for loading heavy equipment through the main cargo doors. The ramps are 27 inches wide and adjustable to two loading angles: a straight-on angle of 24 degrees, or a combination 15- to 30-degree angle. Using the 24-degree angle, the overhead clearance between ramp thread and fuselage is 84 inches. Using the 15-to 30-degree angle, the clearance is 98 inches.

4—19 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-97 aircraft:

Forward	8.0
Aft	1.5
Side	1.5
Vertical	2.5



NOTE:
CARGO DOORS SHOWN REMOVED FOR CLARITY

FIGURE 4–20. MAIN CARGO DOOR AND RAMPS, C-97 AIRCRAFT

TABLE 4–3. MAXIMUM PACKAGE SIZE, FORWARD CARGO HATCH, C-97 AIRCRAFT

		SECOND DIMENSION (IN.)										
FIRST DIMENSION (IN.)		4	8	12	16	20	24	28	32	36	40	42
	4	168	168	167	167	167	166	166	90	80	72	69
	8	168	166	166	166	165	165	164	90	80	72	69
	12	167	166	153	152	152	151	150	89	80	72	69
	16	167	166	152	132	132	131	130	89	73	72	68
	20	167	165	152	132	117	117	116	88	79	71	68
	24	166	165	151	131	117	105	104	88	79	71	68
	28	166	164	150	130	116	104	96	87	78	70	67

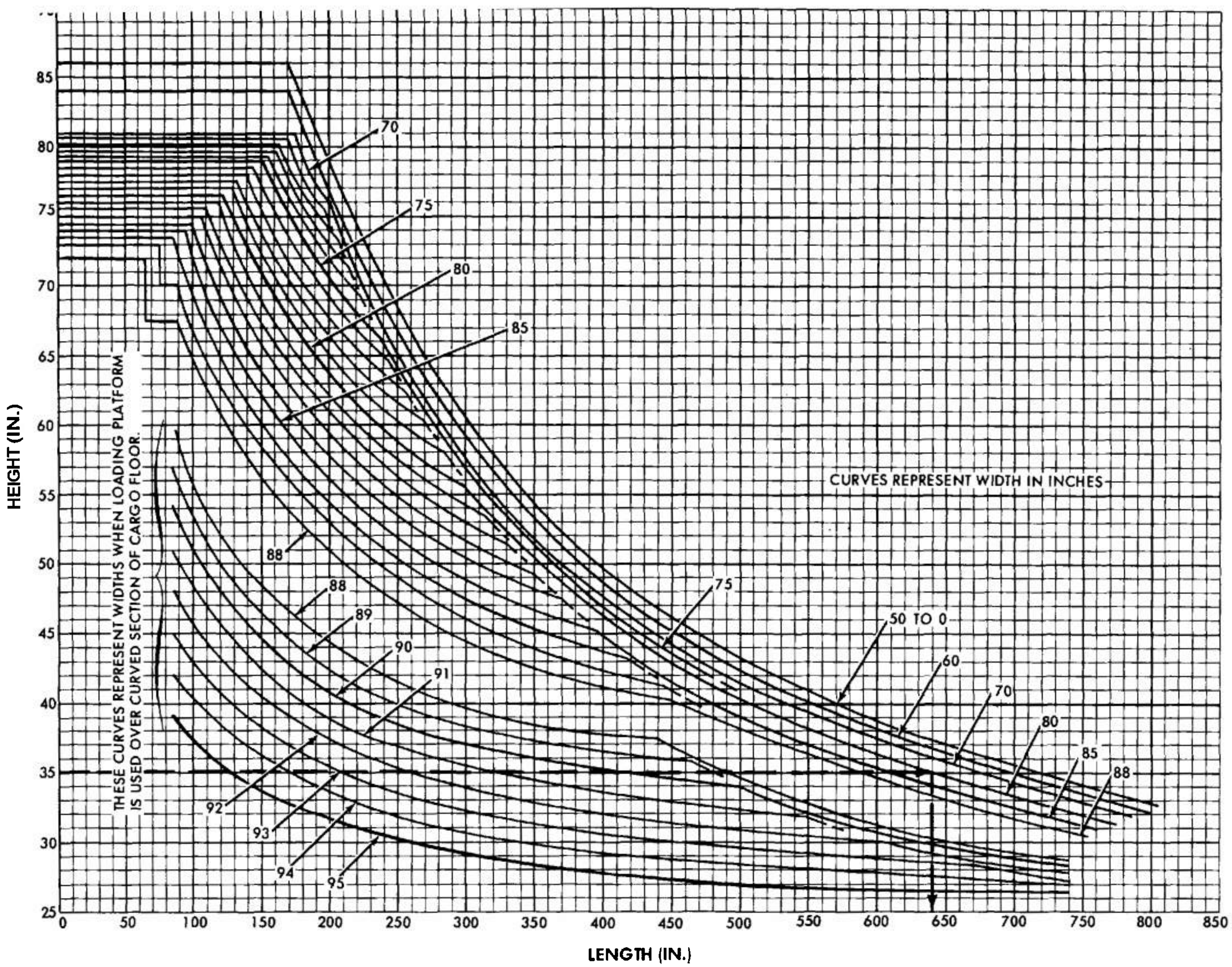


FIGURE 4-21. MAIN CARGO DOOR PACKAGE SIZE GRAPH, C-97 AIRCRAFT

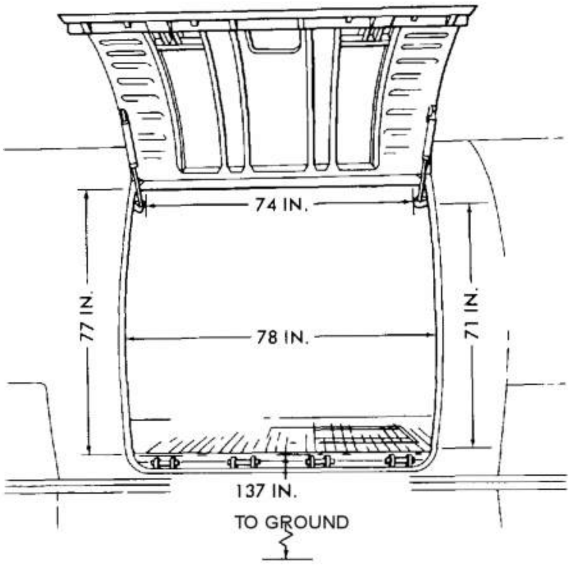


FIGURE 4-22. FORWARD CARGO DOOR, C-97 AIRCRAFT

A 2 0 CARGO LOADING AND UNLOADING PROVISIONS

An electrically operated cargo hoist is provided to load and traverse cargo in the main cargo compartment. The hoist can be used in a single-line configuration or, by using snatch blocks, in a double- or triple-line configuration (Fig. **4—26).** The hoist is capable of lifting 2500 pounds in the single-line configuration and 5000 pounds in the double-line configuration. The triple-line configuration is used for towing only, with a capacity of 7500 pounds. A freerolling trolley may be used in conjunction with the hoist trolley to increase the lift capacity to 10,000pounds.

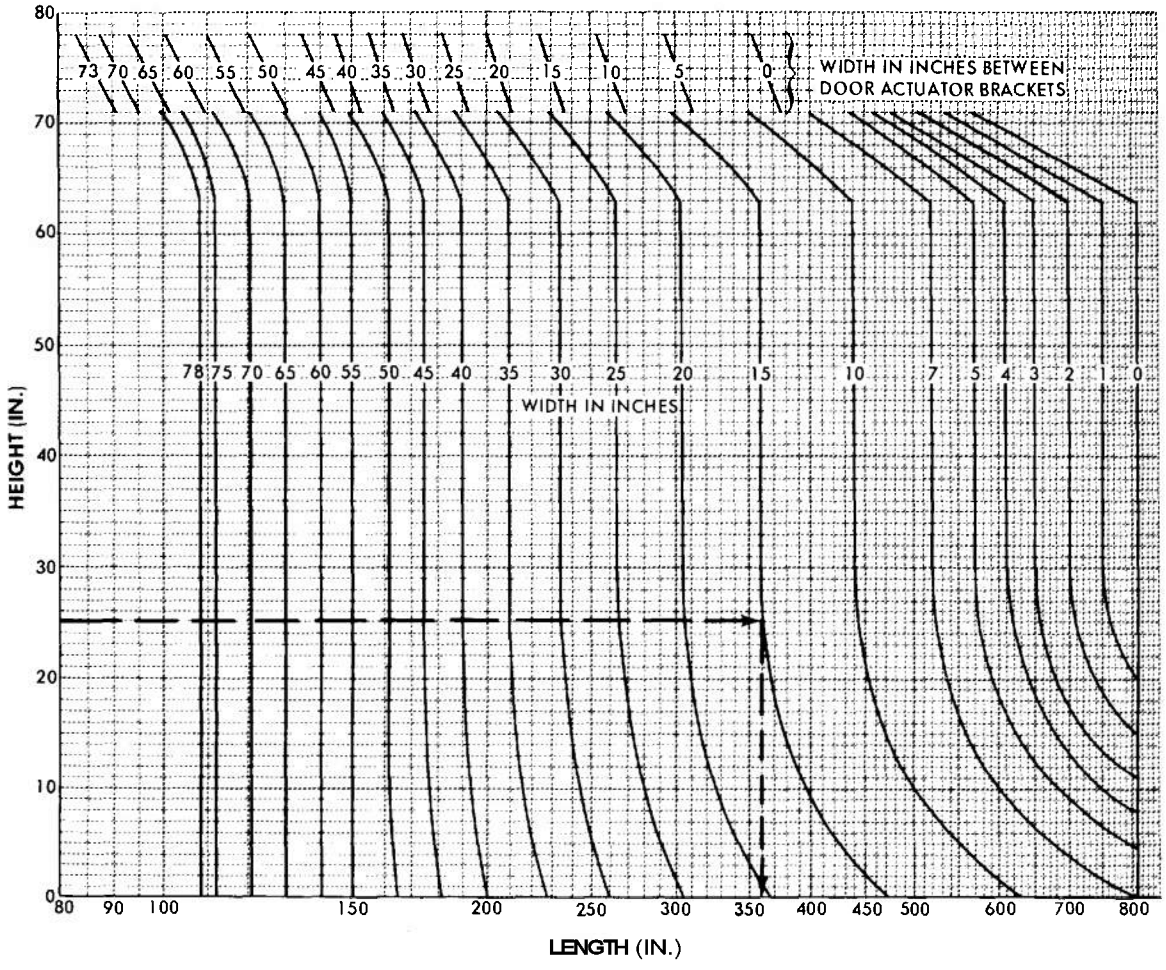


FIGURE 4-23. FORWARD CARGO DOOR PACKAGE SIZE GRAPH, C-97 AIRCRAFT

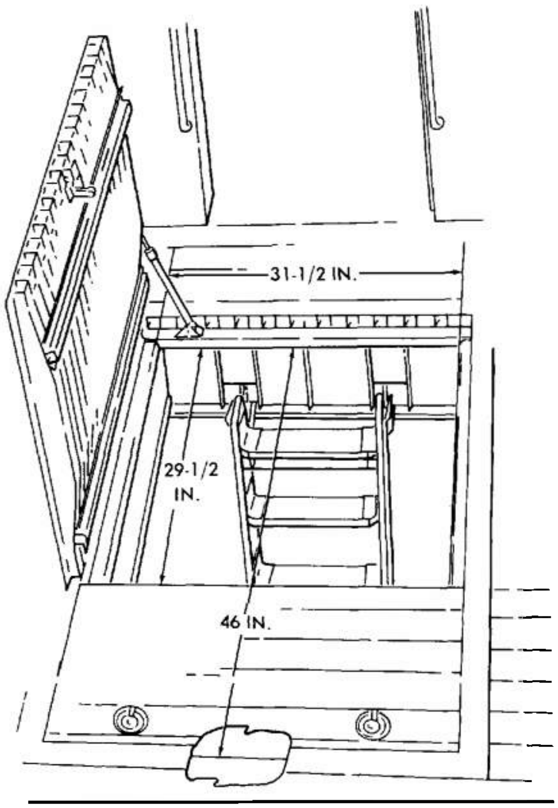


FIGURE 4-24. FORWARD CARGO HATCH, C-97 AIRCRAFT

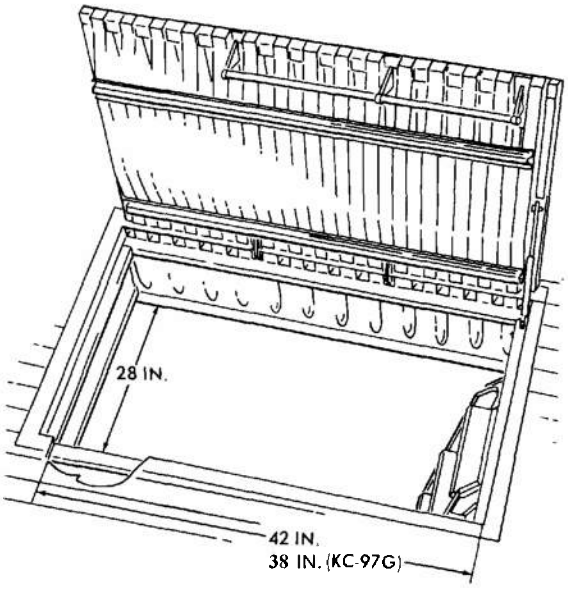


FIGURE 4-25. AFT CARGO HATCH, C-97 AIRCRAFT

TABLE 4-4. MAXIMUM PACKAGE SIZE, AFT CARGO HATCH, C-97 AIRCRAFT

		SECOND DIMENSION (IN.)										
		4	8	12	16	20	24	28	32	36	40	42
FIRST DIMENSION (IN.)	4	155	155	155	155	155	155	155	155	150	125	125
	8	155	130	130	130	130	130	125	125	125	100	100
	12	155	130	110	110	110	110	105	105	105	85	85
	16	155	130	110	95	95	95	95	95	95	70	70
	20	155	130	110	95	85	85	80	80	80	65	65
	24	155	130	110	95	85	70	70	70	70	55	55
	26	155	130	110	95	85	70	55	55	55	45	45

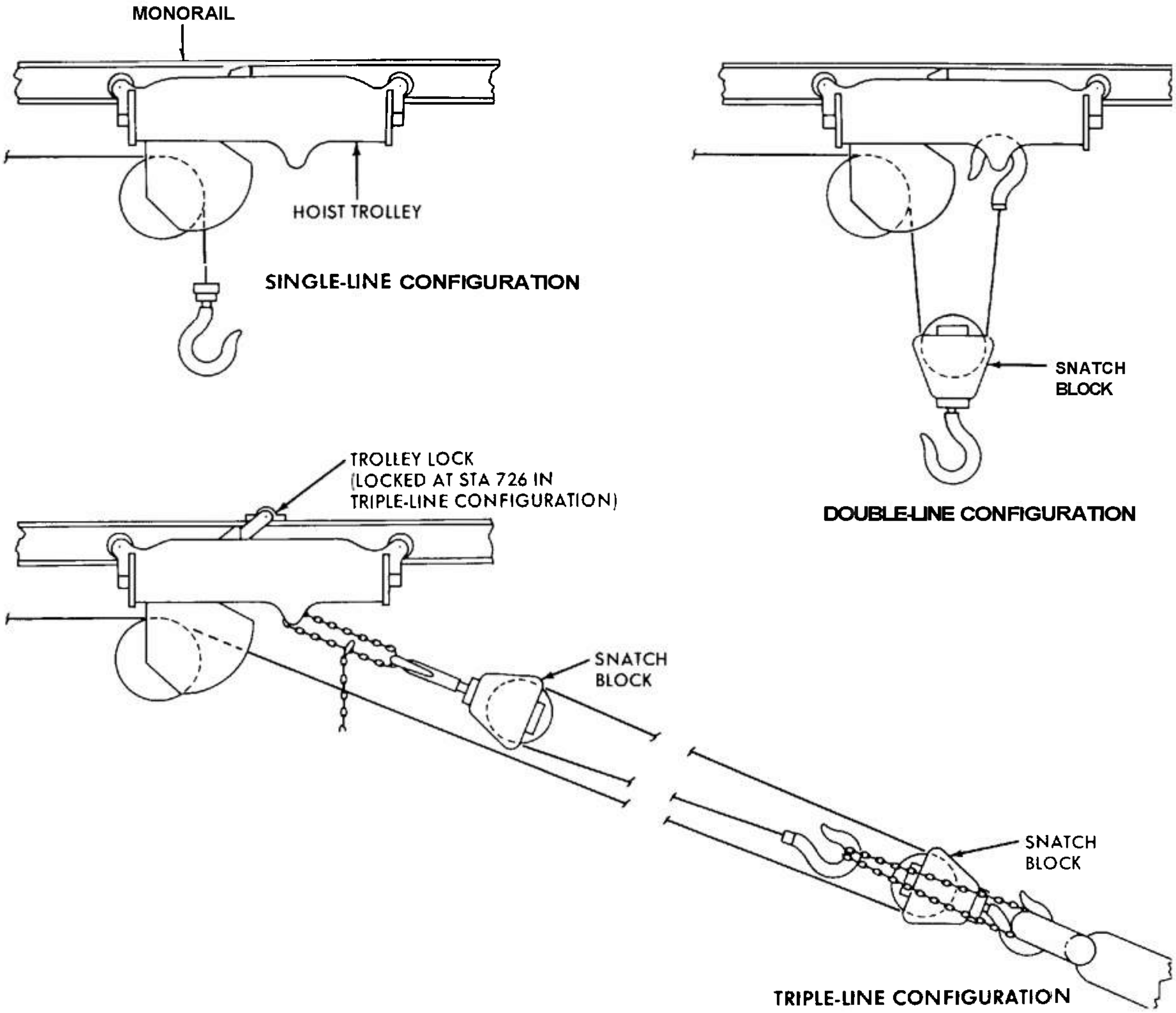


FIGURE 4–26. HOIST ARRANGEMENT, C-97 AIRCRAFT

SECTION V

C-118/DC-6B

4—21 GENERAL DESCRIPTION

The **C-118/DC-6B** is a four-engine, low-wing medium transport (Fig. **4—27**) with a fully retractable tricycle landing gear. The **C-118** is designed as a long-range cargo, troop, or personnel transport, capable of carrying up to **76** passengers or **60** litters. The **C-118** is designed to carry cargo ranging from **24,000** to **26,000** pounds, depending on the amount of fuel, equipment, and other determining factors which decrease the load accordingly. The commercial counterpart of the **C-118,** the Douglas **DC-6B,** was modified to an all-cargo configuration by Pacific Automotive Corporation to carry a maximum cargo payload **of 28,840** pounds.

4—22 CARGO COMPARTMENT

The **C-118** main cargo compartment extends from station **122** to station **938,** with a maximum width of **119** inches and a maximum height of **93** inches (Fig. **4—28).** The lower forward cargo compartment extends from station **89.6** to station **341.** The lower aft cargo compartment extends from station **600** to station **760.** On later aircraft, a cargo annex extends the lower aft cargo compartment to station **845** or **938,** depending on the particular serial number of the aircraft. Total volume of the cargo compartments is approximately **4802** cubic feet, excluding the cargo annex.

The cargo compartment of the commercial **DC-6B** is approximately the same size as the **C-118.** The main cargo compartment is **815** inches long, **105** inches wide at floor level, and **93** inches high, with a total volume of **4433** cubic feet. The lower forward cargo compartment is **251** inches long, **74** inches wide, and **31** inches high, with a total volume of **267** cubic feet. The lower

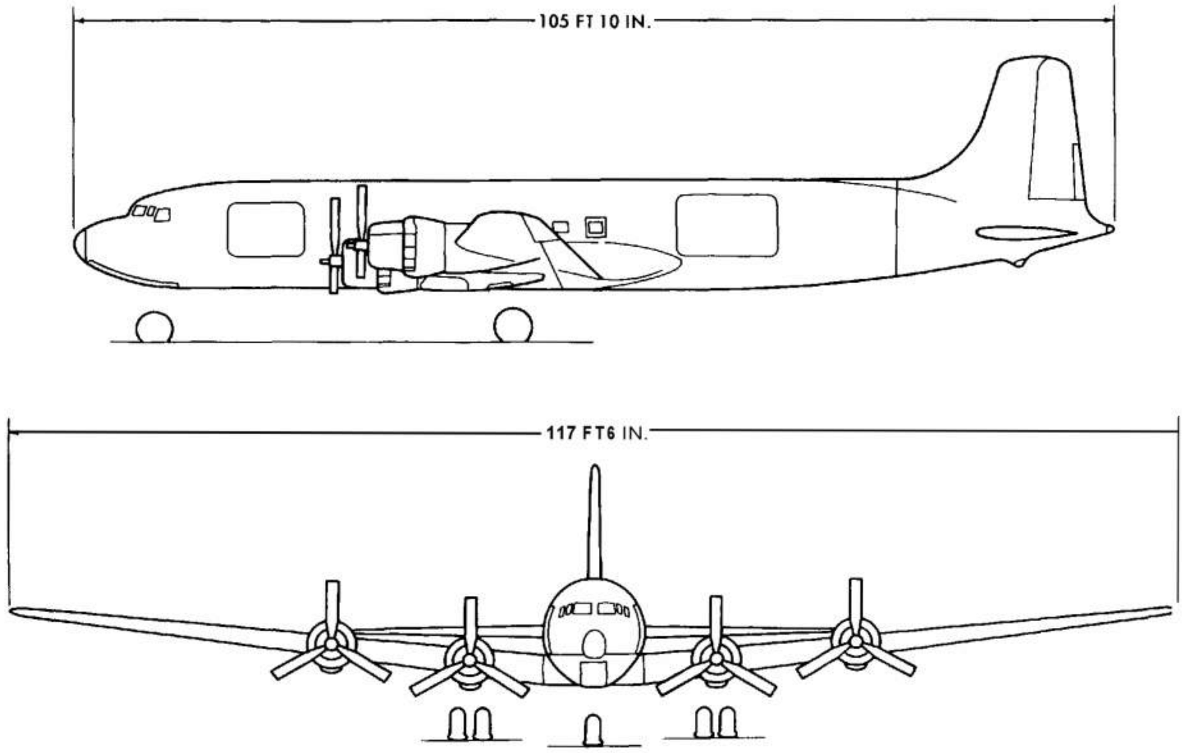


FIGURE 4–27. C-118/DC-6B AIRCRAFT

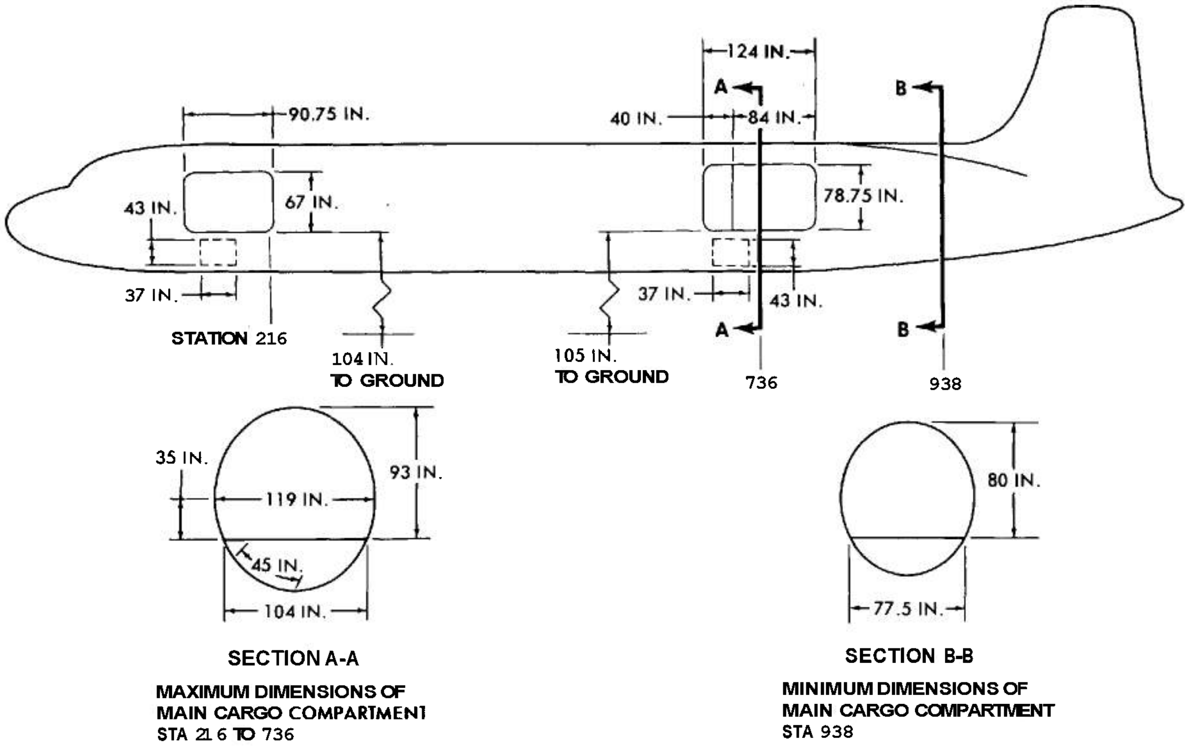


FIGURE 4-28. CARGO COMPARTMENT DIMENSIONS, C-118/DC-6B AIRCRAFT

aft cargo compartment is **243** inches long, **74** inches wide, and **31** inches high, with a total volume of **242** cubic feet.

4-22.1 FLOOR LOADING. The C-118/DC-6B distributed load capacity for the main cargo compartment is 200 pounds per square foot. The lower aft and lower forward cargo compartments have a distributed load capacity of **75** pounds per square foot. Individual cargo compartment maximum weight limitations are shown in Fig. 4-29.

4-22.2 ANCHORING ARRANGEMENT. Cargo floor tiedown fittings for the C-118/DC-6B main cargo compartment are shown in

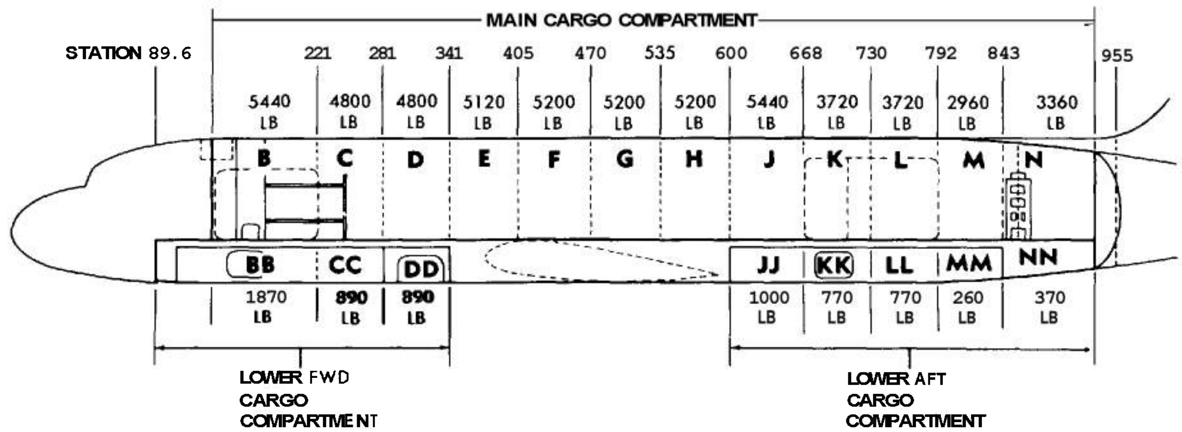


FIGURE 4-29. CARGO COMPARTMENT WEIGHT LIMITS, C-118/DC-6B AIRCRAFT

Fig. 4—30. Tiedown fittings are installed in a 20-inch grid pattern. Permanently attached, swiveling, hinged rings are installed in the main floor tiedown fittings. Twelve heavy-duty fittings, six in the floor and the remainder in the sidewall, are available to restrain heavy cargo in the wing area.

A 2 3 CARGO DOORS

4—23.1 MAIN CARGO DOOR. The C-118/DC-6B main cargo door, located aft of the wing, is in two sections (Fig. 4—28). The aft section, hinged at the top, is hydraulically operated. The forward section of the door is hinged along the front side and opens outward. With both sections of the door fully open, the cargo entrance is 124 inches wide by 78.75 inches high. The height above ground of the main cargo door is 105 inches. Maximum package size for loading through the main cargo door is shown in Table 4—5. To use the table, find the height of the package to be loaded in the upper horizontal column. Find the width dimension in the vertical column. Proceed vertically from the first dimension and horizontally from the second dimension to find the permissible length.

4—23.2 FORWARD CARGO DOOR. The C-118/DC-6B forward cargo door is located on the left side of the fuselage, forward of the propellers (Fig. 4—28). The door is hinged at the top and is hydraulically operated. An opening 90.75 inches wide by 67 inches high and 104 inches above ground is provided with the door fully open. Table 4—6 indicates maximum package size for loading through the forward cargo door. Use the preceding described method to determine if a package can be loaded through either of the cargo compartment doors.

4—23.3 LOWER CARGO COMPARTMENT DOORS. Each of the lower cargo compartments on the C-118/DC-6B is equipped with a 37-inch by 45-inch cargo door on the right side of the fuselage (Fig. 4—28). Table 4—7 indicates a maximum package size for loading through the lower cargo doors.

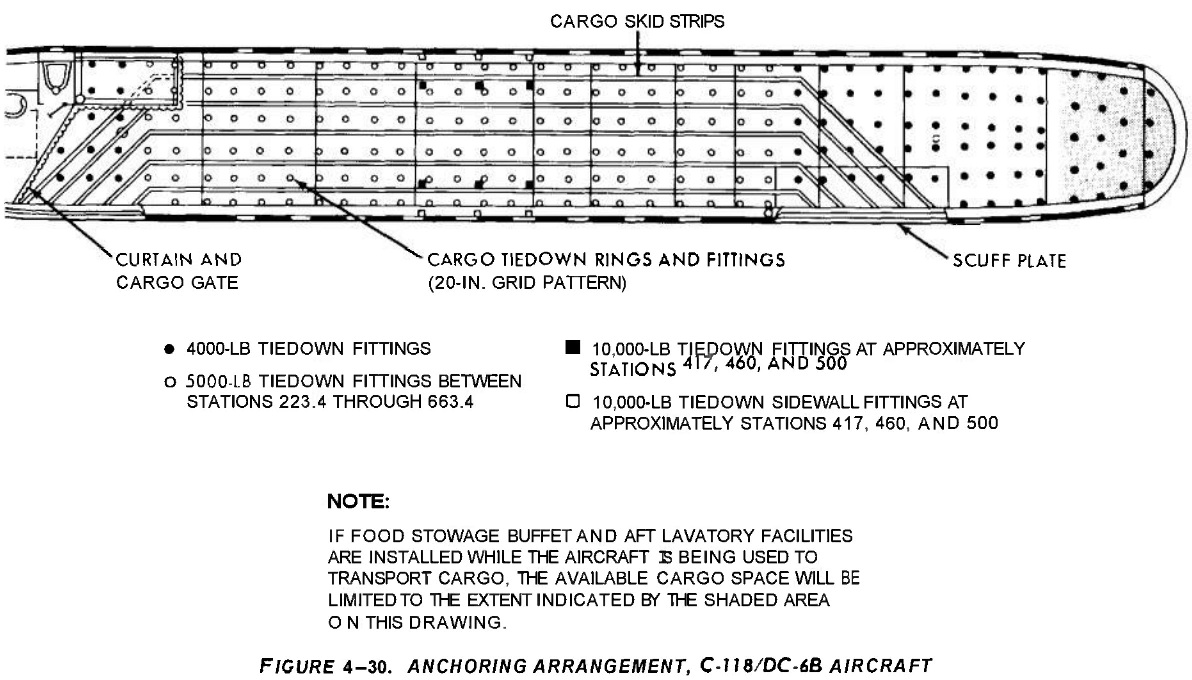


FIGURE 4–30. ANCHORING ARRANGEMENT, C-118/DC-6B AIRCRAFT

TABLE 4-5. MAXIMUM PACKAGE SIZE, MAIN CARGO DOOR, C-118/DC-6B AIRCRAFT

WIDTH (IN.)	HEIGHT (IN.)																		
	60 AND UNDER	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	MAXIMUM LENGTH – (IN.)																		
3	623	623	623	523	523	523	623	623	620	512	598	570	547	521	499	473	446	428	412
6	623	623	623	523	623	623	623	620	605	593	581	542	521	501	476	499	431	418	393
9	623	623	623	523	623	623	623	618	595	579	554	523	494	477	453	438	417	394	382
12	602	601	580	575	560	545	530	511	504	496	472	458	432	417	404	387	372	363	354
15	550	534	519	506	498	489	475	460	445	436	420	403	392	380	369	358	349	341	330
18	484	477	463	152	444	435	424	414	406	398	384	373	361	349	341	330	321	312	302
21	430	421	414	109	401	395	385	376	367	358	350	339	328	321	313	304	298	289	282
24	398	390	385	379	368	363	359	348	339	330	326	322	319	308	299	291	284	279	271
27	365	358	350	347	341	336	329	322	315	307	298	289	281	278	272	269	266	263	259
30	336	330	328	324	319	311	304	300	294	286	279	271	264	260	257	254	251	247	245
33	318	311	307	301	298	292	287	282	278	271	263	255	248	244	239	235	231	227	224
36	290	286	284	282	280	276	272	267	263	256	249	243	235	231	228	224	219	216	213
39	274	271	269	267	264	260	256	251	248	242	237	230	224	219	215	211	205	201	198
42	259	256	254	252	250	247	243	238	235	230	225	219	214	210	204	199	196	193	189
45	247	244	242	240	238	235	231	226	223	218	213	208	204	201	197	193	189	185	181
48	234	232	230	228	226	223	218	214	211	208	204	199	196	192	188	185	181	177	175
51	222	220	218	216	214	210	207	203	200	195	191	188	184	180	177	174	172	170	168
54	210	208	206	205	202	198	195	193	191	188	185	181	179	173	171	168	165	163	162
57	198	196	194	192	190	187	185	183	182	178	175	173	171	167	164	162	159	157	155
60	189	186	184	182	180	178	176	174	173	171	170	169	168	163	160	158	155	153	149
63	181	179	177	175	173	170	168	166	165	163	160	158	156	154	151	149	146	144	142
66	174	171	169	167	165	164	162	160	159	156	154	152	151	148	146	144	142	140	138
69	169	166	163	161	160	159	158	154	152	150	148	147	146	144	141	139	137	135	134
72	163	161	158	156	153	151	150	148	146	145	143	142	141	139	137	136	134	132	130
75	157	155	152	150	147	145	144	142	140	139	138	137	135	134	132	130	128	126	
78	151	149	146	144	141	139	138	136	134	133	132	131	130	128	126	123	121	118	
81	146	143	140	138	135	133	131	130	129	128	127	126	125	122	120	116	115		
84	141	138	135	132	129	128	127	126	125	124	123	122	120	118	115				
87	136	133	130	127	124	122	121	119	118	117	115	114	113						
90	132	128	125	122	121	120	118	117	116	115	112								
93	127	124	122	119	116	115	114	113	112	111									
96	124	121	119	116	114	113	112												
99	120	118	116	114	112														
102	117	115																	
103	115																		

4-24 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-118 aircraft:

Forward	1.34
Aft	1.29
Side	1.00
Vertical	2.47

4-25 CARGO LOADING AND UNLOADING PROVISIONS

An electrically operated winch is provided to move cargo within the aircraft. The winch is portable and may be attached at any seat stud fitting.

The C-118 aircraft is equipped to accommodate an electrically actuated portable litter lift. The litter lift is capable of on or off loading two litters, or miscellaneous cargo not to exceed 500 pounds.

Provisions are also installed at the forward and aft cargo doors to accommodate a 4000-pound capacity portable cargo lift.

TABLE 4-6. MAXIMUM PACKAGE SIZE, FORWARD CARGO DOOR, C-118/DC-6B AIRCRAFT

WIDTH (IN.)	HEIGHT (IN.)																		
	48 AND UNDER	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
	MAXIMUM LENGTH – (IN.)																		
3	623	623	623	623	623	621	590	571	562	549	536	524	510	491	463	445	421	413	402
6	603	602	602	601	601	567	542	523	506	479	461	453	444	425	409	389	381	372	364
9	566	566	566	565	565	542	520	501	482	461	447	423	405	384	365	348	331	319	307
12	490	490	489	489	488	472	448	431	416	402	389	376	362	349	332	309	291	289	284
15	425	425	424	424	423	412	395	380	368	357	348	337	325	312	303	291	283	275	264
18	372	372	371	370	370	359	342	336	327	319	311	297	294	285	274	268	259	254	248
21	330	330	329	328	327	318	304	298	291	286	279	276	270	263	259	250	246	240	233
24	291	291	290	289	288	288	286	282	273	264	261	257	248	242	236	231	227	221	217
27	272	272	271	270	269	269	259	254	249	245	240	236	232	226	222	219	214	210	206
30	251	251	250	249	248	245	237	233	230	227	224	221	218	216	213	209	207	199	196
33	232	230	228	225	221	219	216	213	211	210	209	207	205	201	198	196	194	192	188
36	216	214	211	208	206	204	201	200	198	197	196	194	193	189	187	185	183	179	177
39	204	201	199	197	196	194	191	189	187	186	184	182	180	176	174	174	172	170	168
42	192	190	188	186	185	183	180	178	176	174	171	170	168	166	165	164	162	160	160
45	181	179	177	175	173	172	170	167	163	160	158	157	156	155	155	154	154	153	152
48	174	172	171	171	170	170	168	165	161	154	149	146	142	142	142	142	142	142	142
51	160	157	155	153	153	151	150	148	146	143	141	138	135	135	135	135	135	135	135
54	152	150	148	146	145	144	144	141	137	133	131	129	127	127	127	127	127	127	127
57	145	143	141	139	138	137	137	133	130	125	123	120	118	118	118	118	118	118	118
60	138	136	134	133	132	131	131	127	124	120	118	114	111	111	111	111	111	111	111
63	131	129	128	127	126	125	122	118	116	114	112	107	104	104	104	104	104	104	104
66	123	121	120	119	118	115	74	74	74	74	74	74	74	70	70	70	70	70	70
69	120	118	113	110	105	100	74	74	74	74	74	74	74	70	70	70	70	70	70
72	116	112	110	105	101	87	74	74	74	74	74	74	74	70	70	70	70	70	70

TABLE 4-7. MAXIMUM PACKAGE SIZE, LOWER AFT AND LOWER FORWARD CARGO DOORS, C-118/DC-6B AIRCRAFT

WIDTH (IN.)	HEIGHT (IN.)															
	6	9	12	15	16	17	18	19	20	21	22	23	24	25	26	27
	MAXIMUM LENGTH (IN.)															
3	160	160	160	160	160	160	158	149	142	137	131	126	120	111	104	100
6	160	160	160	160	160	153	147	141	135	128	121	116	112	105	97	91
9	160	160	160	150	144	139	135	128	123	117	113	108	104	94	89	82
12	160	160	158	141	135	129	124	118	113	109	106	101	97	92	81	74
15	160	160	142	127	122	118	114	109	104	101	98	94	90	79	72	67
18	150	135	123	114	111	108	105	101	97	95	91	87	84	77	69	60
21	124	116	108	99	96	95	94	90	87	84	82	79	77	68	61	54
24	112	104	96	91	88	86	84	81	78	76	74	72	70	61	54	48
27	99	95	89	82	79	78	77	74	72	70	69	66	64	53	49	43
30	88	86	80	74	72	72	71	69	67	65	63	61	58	49	43	39
33	80	79	75	70	68	67	66	64	62	60	57	54	53	45	41	36
36	71	71	69	66	64	62	61	59	58	56	53	50	48	42	38	34

SECTION VI

C-119

4-26 GENERAL DESCRIPTION

The C-119 is a high-wing, twin-engine, twin-boom, medium transport (Fig. 4-3 1). Its principal mission is to transport cargo, personnel, or litters. In addition, it is used for airdrop. Removable clamshell or flight operable doors permit airdrop of heavy equipment from the aft end. It is also equipped with an interior overhead monorail for inflight discharge of supplies or equipment through the monorail door. Capacity of the monorail is twenty 500-pound air delivery containers (10,000 pounds).

4-27 CARGO COMPARTMENT

The cargo compartment extends from station 106 to station 549 and provides a level, continuous, unobstructed area for cargo loading. Critical contours of the cargo compartment are shown in Fig. 4—32. Dimensions of the cargo compartment are shown in Figs. 4—33 and 4—34. For airdrop, the dimensions are limited to 371 inches long, 105 inches wide, and 86-3/4 inches high. Maximum volume of the cargo compartment is 3150 cubic feet with the clamshell or flight operable doors installed. With the doors removed, the maximum volume is 2850 cubic feet. The entire nonskid area of the cargo compartment is made of 3,8-inch, 5-ply plywood. Metal wear strips, spaced 10 inches apart, are used to protect the flooring.

The maximum load that may be extracted from the C-119 during airdrop operations is 14,000 pounds; the minimum

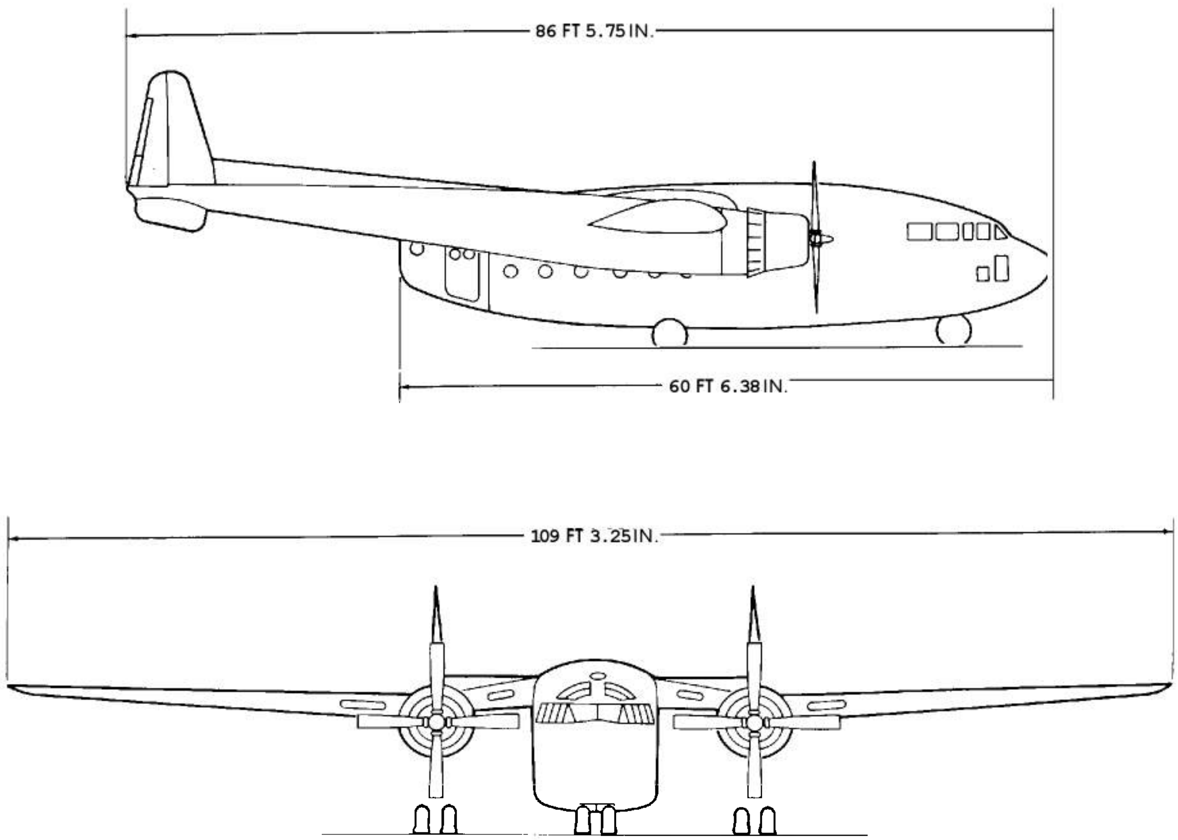


FIGURE 4-31. C-119 AIRCRAFT

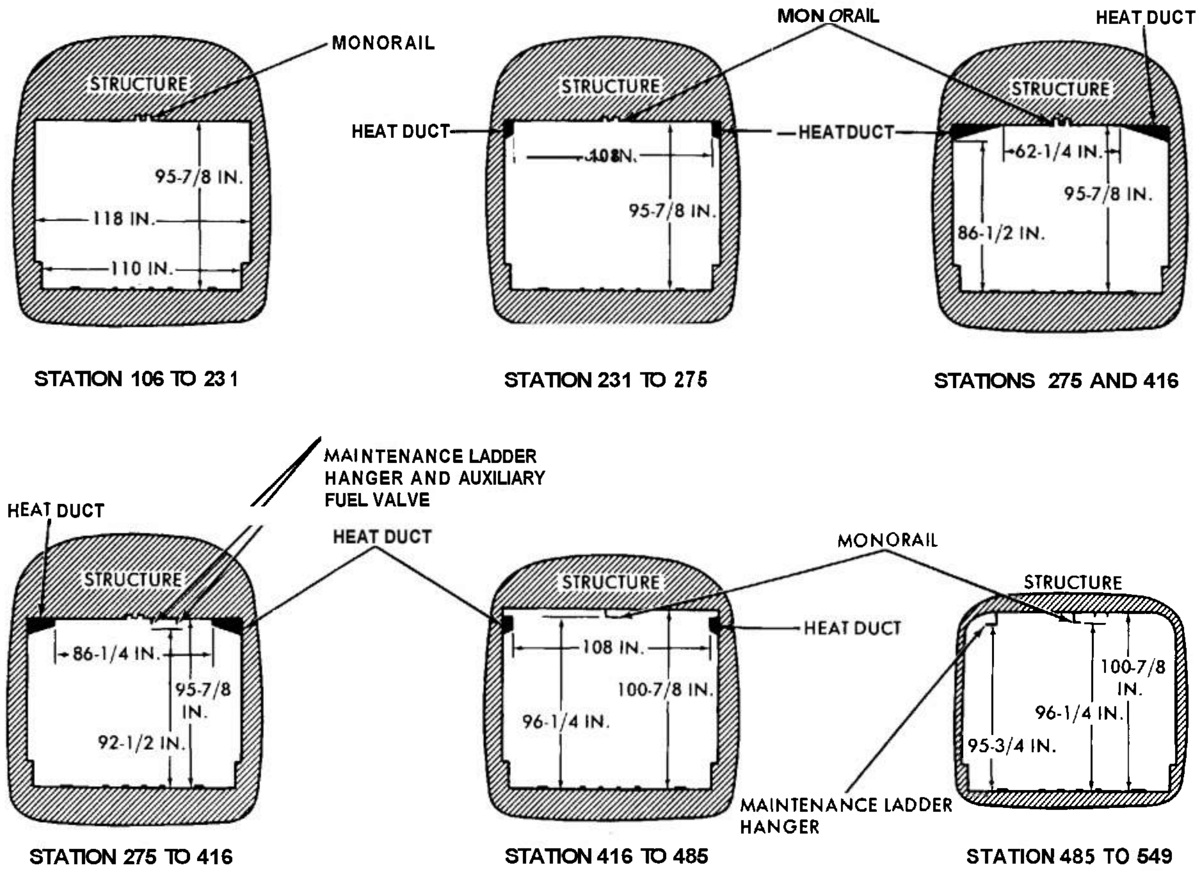


FIGURE 4-32. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-119 AIRCRAFT

is **1750** pounds. Loads are extracted from the aft end utilizing the floor level wheeled conveyor system and gravity, or an extraction parachute to supply the ejection force.

4-27.1 FLOOR LOADING. The cargo floor and supporting structure are designed for a uniformly distributed load of 200 pounds per square foot and a maximum vehicle tire pressure of 50 pounds per square inch. The treadways will support an axle load up to 15,500 pounds. Figure 4-35 illustrates total load limits for individual compartments. Additional loading space is available in the cargo doors as follows:

If the aircraft incorporates the clamshell-type doors, the cargo door floor strength is *56* pounds per square foot. A total load of 2000 pounds may be loaded on the lower level or 900 pounds on the upper level. If both levels are loaded simultaneously, the load limit of the lower level is 890 pounds and the upper level is 400 pounds.

If the aircraft incorporates the flight-operable type doors, the cargo door floor strength is 200 pounds per cubic foot. The maximum allowable load between stations 549 and 602 is 1340 pounds (not to exceed 530 pounds total on the removable floor sections between stations 549 and 563). The floor area aft of station 602 is not suitable for loading general cargo.

4-27.2 ANCHORING ARRANGEMENT. A total of 166 tiedown points is provided on the cargo floor. Seventy-eight of these tiedown points are on the main frame and center beam of the floor structure. The location and rating of these fittings are shown in Fig. 4-36. Eighty-eight 1250-pound cargo fittings are equally spaced on 20-inch centers over the entire compartment flooring. In addition,

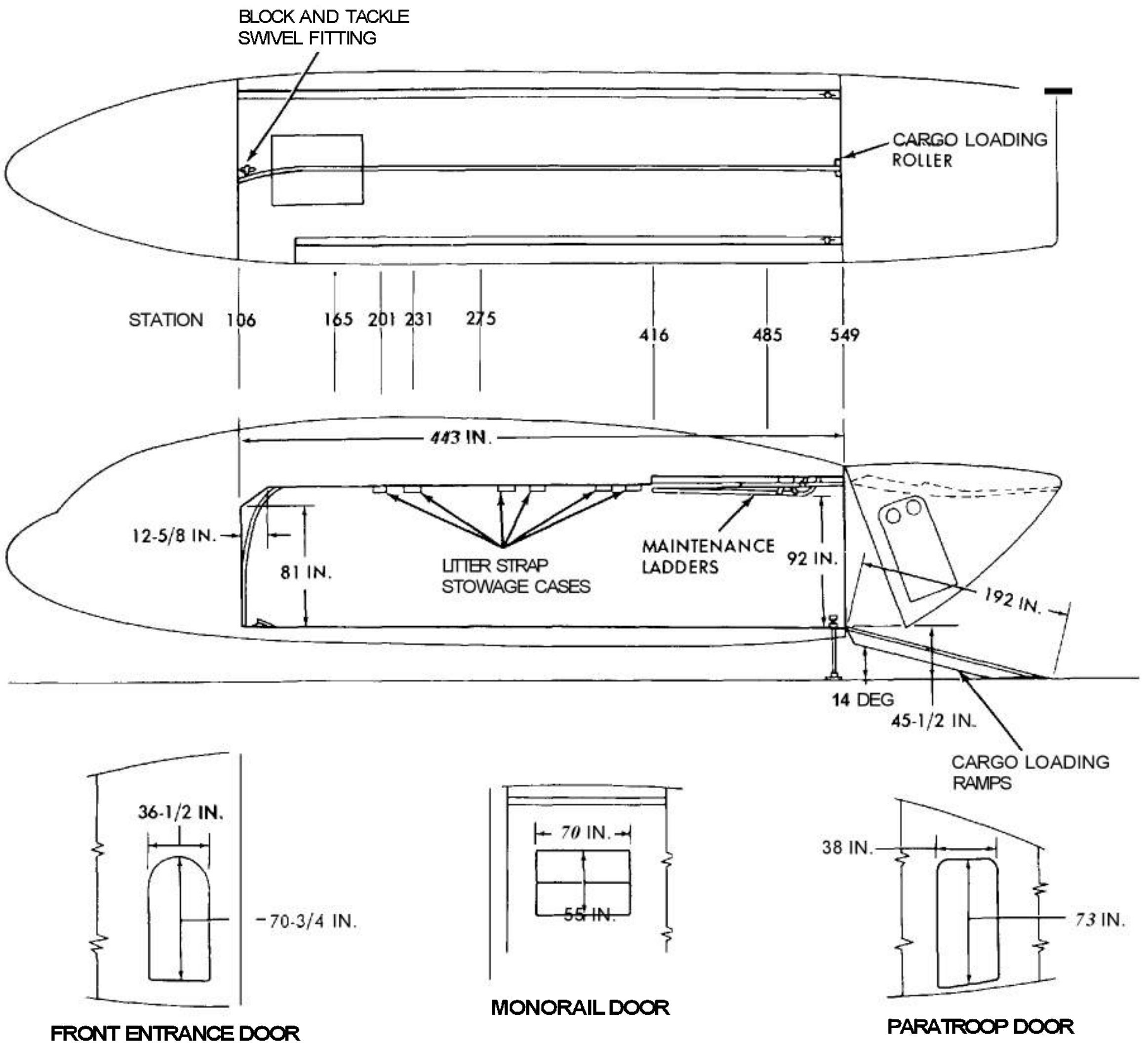


FIGURE 4–33. CARGO COMPARTMENT DIMENSIONS, C-119 AIRCRAFT (FLIGHT OPERABLE DOORS)

forty 10,000-pound tiedown rings, USAF Drawing No. **48B7796,** are stowed in the aft fuselage.

4–28 CARGO DOORS AND RAMPS

4–28.1 CARGO DOORS. Four sets of doors are provided in the cargo compartment (Figs. **4–33** and **4–34).** The front entrance door is located at the left forward side of the cargo compartment and is used primarily for loading and unloading of personnel. Main cargo doors are installed on the aft end of the cargo compartment, and provide an opening of **110.4** inches wide and **96** inches high. On most **C-119** aircraft, these doors are of the clamshell type, hinged on either side of the fuselage. These doors may be swung outward for handling cargo; for airdrop of heavy equipment, they are removed completely. **A** smaller, removable, jump door is installed in each of these main cargo doors, primarily for use as a paratroop exit. On some **C-119** aircraft, a flight operable door is installed in lieu of the clamshell doors. This configuration consists of a wedge-shaped hood, hinged on the top of the fuselage, supporting a movable floor section that is hinged at the aft ends of the hood. Both components can be operated

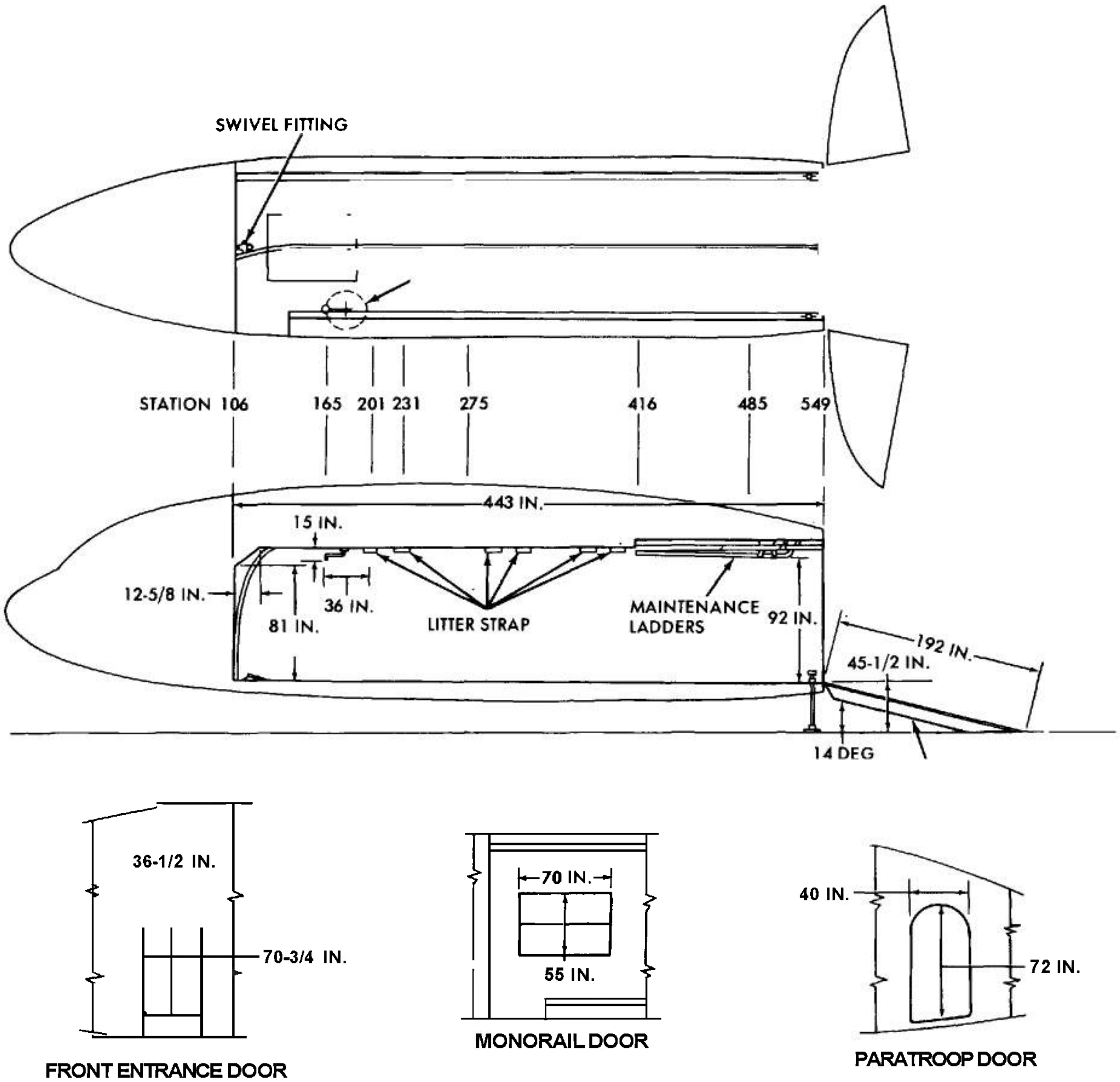


FIGURE 4–34. CARGO COMPARTMENT DIMENSIONS, C-119 AIRCRAFT (CLAMSHELL-TYPE DOORS)

hydraulically, either in flight or on the ground. Paratroop exit doors are also installed in either side of the hood.

A monorail door is located between stations 119 and 201 on the aircraft floor for airdrop of bundle loads. This door is 55 inches wide and 70 inches long; however, certain restrictions are imposed on the opening where it is used for airdrop of bundles utilizing the overhead monorail. To assure that bundles do not exceed the space allowed for satisfactory delivery, the following size limitations must be adhered to (Fig. 4–37):

a. Width of bundles shall not exceed 32 inches, due to spacing of the guide curtains used to prevent excessive side motion or swaying of bundles during flight.

b. Length of bundles (with respect to the aircraft) shall not exceed 36 inches.

c. Height of bundles shall not exceed 62 inches if bundle length is 20 inches or less. Height shall not exceed 48 inches for a

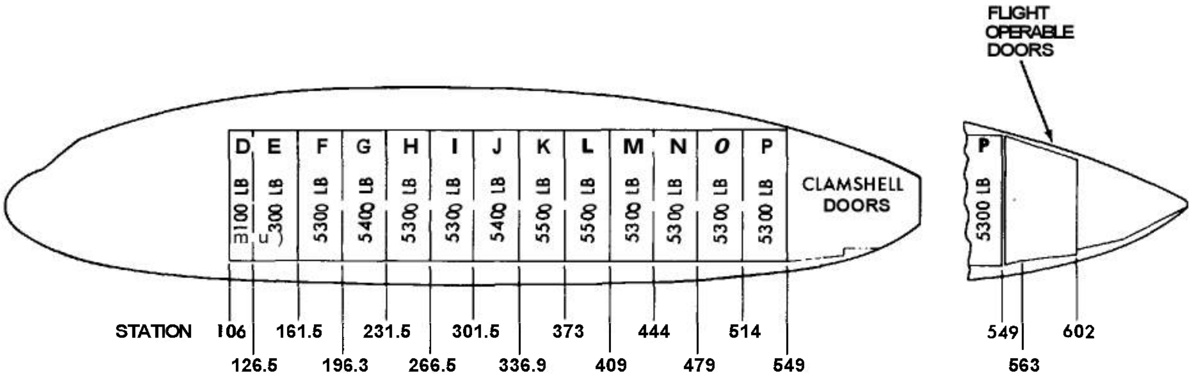


FIGURE 4-35. CARGO COMPARTMENT WEIGHT LIMITS, C-119 AIRCRAFT

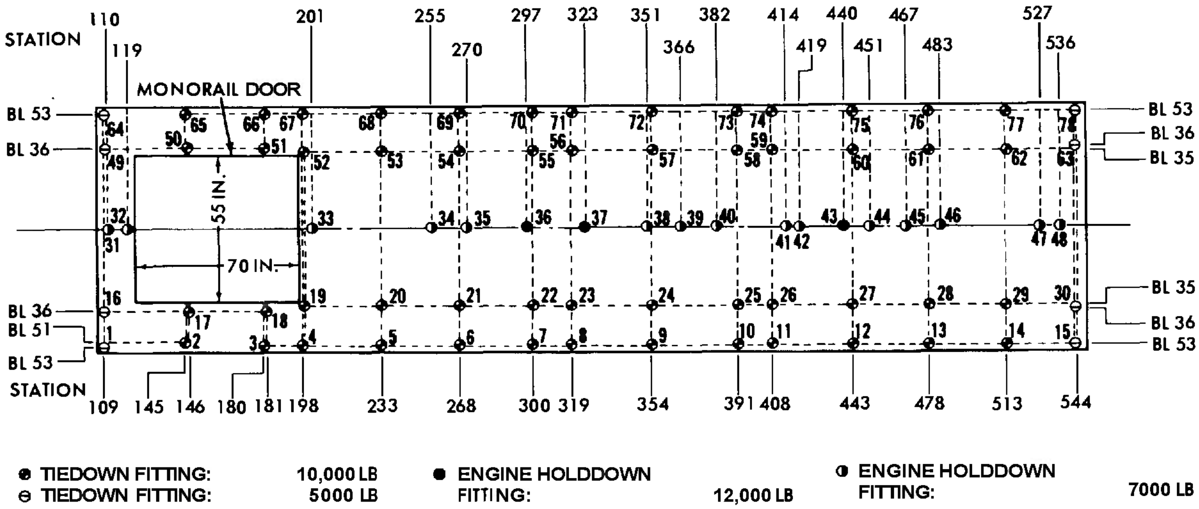


FIGURE 4-36. ANCHORING ARRANGEMENT, C-119 AIRCRAFT

bundle length of **30** to **36** inches. Maximum height of bundles having a length between **20** and **30** inches can be determined from Fig. **4—37.** For example, the maximum height for a bundle 27 inches long is 52 inches.

4—28.2 RAMPS. Two loading ramps (Figs. **4—33** and **4—34)** with a limit of **9400** pounds per ramp are provided to facilitate loading through the aft cargo doors. Provisions are made for attaching the ramps to the cargo door sill. Length of the ramps is **192** inches. Provisions for predetermining loading ramp positions **for** frequently transported vehicles are incorporated on the aft face of the fuselage frame at station **549.**

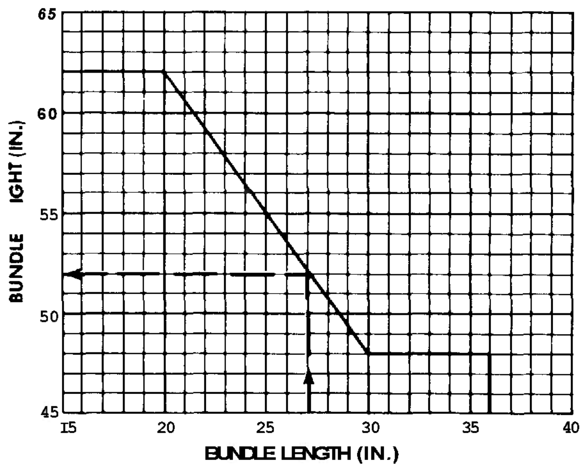


FIGURE 4-37. MONORAIL PACKAGE SIZE GRAPH, C-119 AIRCRAFT

4—29 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-119 aircraft:

Forward	4.5
Aft.	1.5
Side	1.5
Vertical	2.25

4—30 CARGO LOADING AND UNLOADING PROVISIONS

Two detachable, threaded loading ramps are provided to facilitate vehicle loading (Figs. 4—33 and 4—34). A block-and-tackle swivel fitting is provided in the forward end of the cargo compartment for winching. When the motivating force is placed at the rear of the aircraft, the maximum permissible pulling force which the swivel will withstand is 3160 pounds, equivalent to towing a 13,000-pound wheeled vehicle up the ramps. If the cable is routed out the front entrance door, the maximum permissible pulling force the swivel will withstand is 1850 pounds, equivalent to pulling a 7650-pound wheeled vehicle up the loading ramps. The tow cable should not be used to position large crates unless the crates are on rollers. A cargo loading roller is installed at floor level at the aft end of the cargo compartment to facilitate loading. Jacks, located at the rear corner of the cargo compartment, are used to support the fuselage when ramp loading vehicles over 9000 pounds. If the load on each jack exceeds 10,357 pounds, an additional aft frame support shall be used[15].

SECTION VII

C-121/1049H

4-31 GENERAL DESCRIPTION

The C-121 is a four-engine, low-wing, heavy transport (Fig. 4—38). There are two models of this aircraft used as an over-water cargo, personnel, and evacuation transport — the C-121C and the C-121G. The C-121 is capable of carrying 78 passengers or up to 47 litters. This aircraft does not have provisions for parachutist or for airdrop of cargo.

The commercial version of the C-121, the Lockheed Super Constellation Model 1049H, is designed for transporting cargo. It can be converted to an all-passenger configuration.

4-32 CARGO COMPARTMENT

The **C-121/1049H** has three separate cargo compartments: main, lower forward, and lower aft. The C-121 main cargo compartment extends from station 285 to station 1258 with a floor area of 727 square feet and has a maximum volume of 4770 cubic feet. The 1049H main cargo compartment extends from station 260 to station 1258. It has a floor area of 744 square feet and a maximum volume of 4875 cubic feet. The C-121/1049H lower forward cargo compartment extends from station 333.6 to station 638.0 and has a floor area of 112 square feet. The **C-121/1049H** lower aft cargo compartment extends from station 750.4 to station 1139.8 and has a floor area of 176 square feet. Dimensions of the cargo compartments are shown in Fig. 4—39.

4-32.1 FLOOR LOADING. Flooring for the main cargo compartment is constructed of extruded magnesium except approximately 100 inches of the aft floor, which is plywood with a smooth, metal surface. Both lower compartments are completely lined with removable, laminated, plasticized,

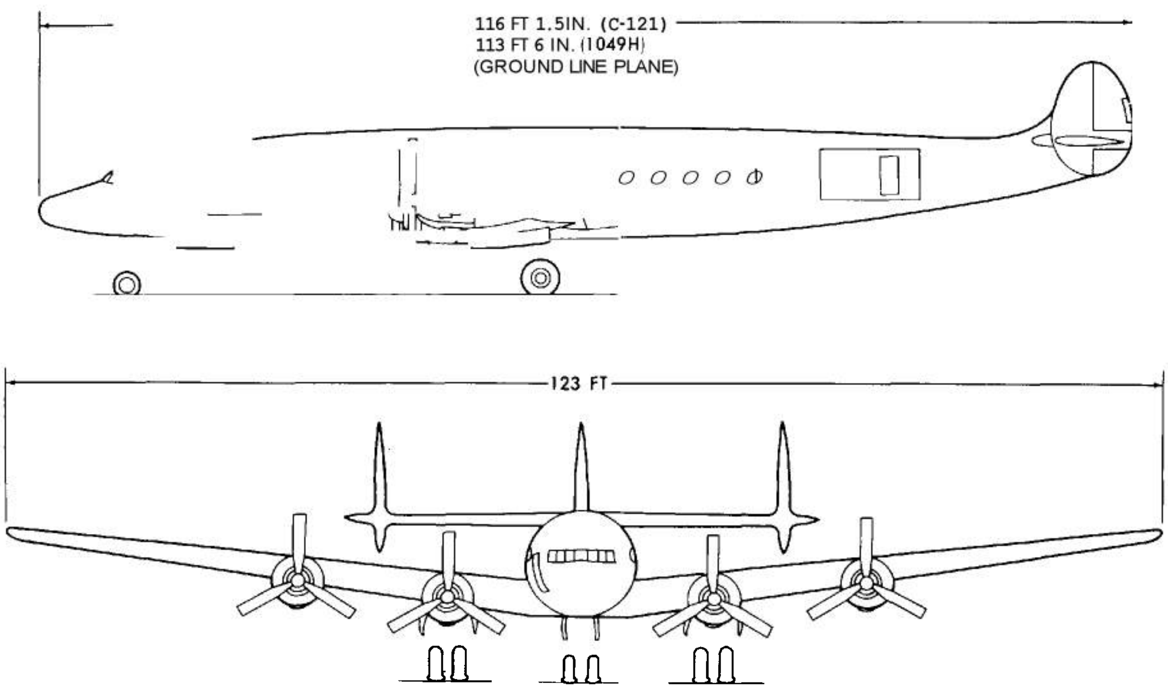
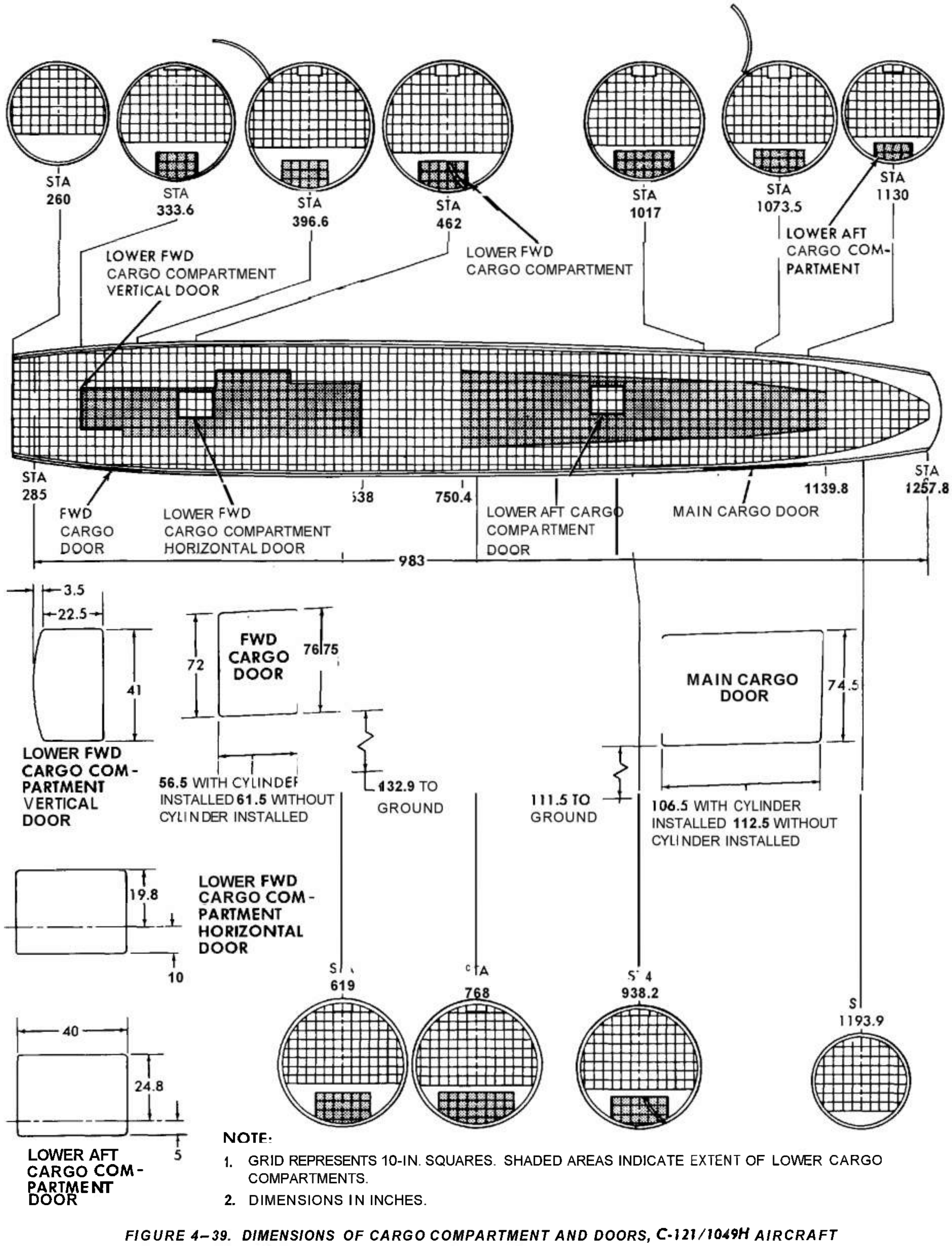


FIGURE 4–38. C-121/1049H AIRCRAFT



NOTE:

1. GRID REPRESENTS 10-IN. SQUARES. SHADED AREAS INDICATE EXTENT OF LOWER CARGO COMPARTMENTS.
2. DIMENSIONS IN INCHES.

FIGURE 4-39. DIMENSIONS OF CARGO COMPARTMENT AND DOORS, C-121/1049H AIRCRAFT

F'iberglas sheet. The allowable running load for the main cargo floor is 1000 pounds per foot between stations **334** and 1158. A running load of 500 pounds per foot is permissible forward of station **334** and aft of station 1158. The average loading per square foot for the main cargo floor must not exceed **300** pounds. Individual cargo compartment maximum weight limitations are shown in Fig. **4-40.**

4—32.2 ANCHORING ARRANGEMENT. Cargo floor tiedown fittings for all compartments are shown in Fig. 4-41. These fittings are arranged in a 20-inch grid pattern. In addition to the fittings shown in Fig. 4-41, the main cargo compartment is equipped with 124 sidewall fittings with a 2250-pound capacity each. The main cargo floor is also equipped with stud-type fittings for installation of passenger chairs, partitions, and equipment.

4—33 CARGO DOORS

The cargo compartments have five cargo doors, two each for the main and lower forward compartments and one for the lower aft compartment.

4—33.1 MAIN CARGO DOOR. The main cargo door (Fig. **4—39)** provides an opening to the main cargo compartment 74.5 inches

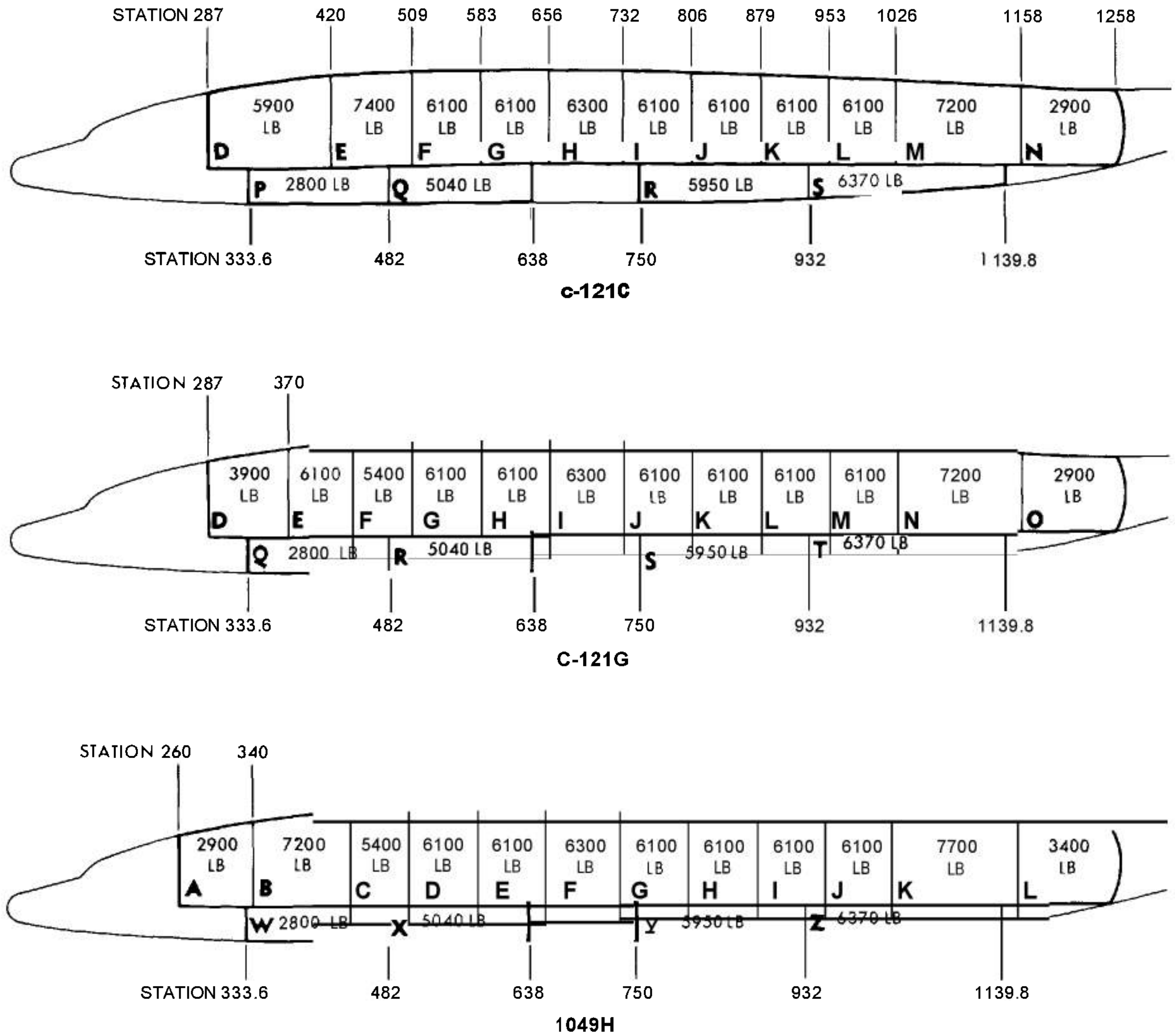


FIGURE 4-40. CARGO COMPARTMENT WEIGHT LIMITS, C-121/1049H AIRCRAFT

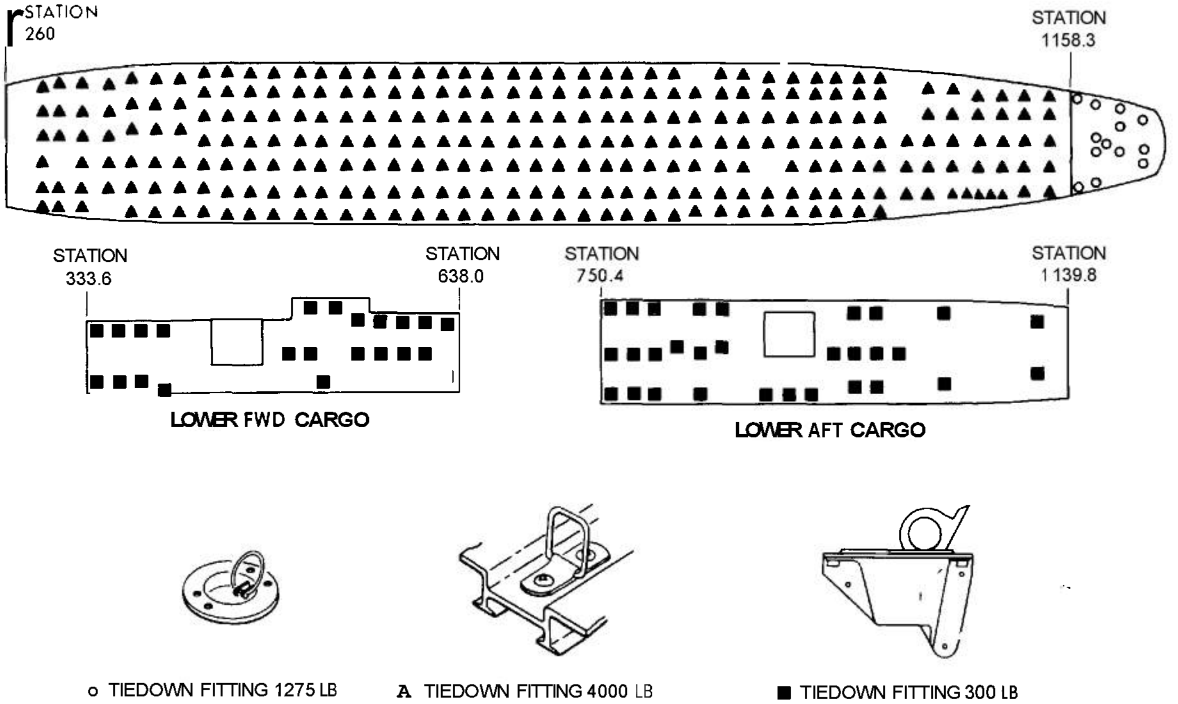


FIGURE 4-41. ANCHORING ARRANGEMENT, C-121/1049H AIRCRAFT

high and 112.5 inches wide with the door actuating cylinder removed. The width is reduced to 106.5 inches when the cylinder is installed. The height above ground of the main cargo door is 111.5 inches. Figure 4—42 indicates maximum package size for loading through the main cargo door. The example chase line on Fig. 4-42 indicates a package 49 inches high by 50-1/2 inches wide can be loaded, providing the length does not exceed 240 inches.

4—33.2 FORWARD CARGO DOOR. The forward cargo door (Fig. 4—39) is located between stations 333 and 398. Figure 4—43 indicates maximum package size for loading through the forward cargo door. The example chase line on Fig. 4-43 indicates a package 12 inches high by 27 inches wide can be loaded, providing the length does not exceed 240 inches.

4—33.3 LOWER CARGO COMPARTMENT DOORS. The lower forward cargo compartment vertical door (Fig. 4—39) is located in the rear bulkhead of the nose wheel well. Figure 4-44 indicates maximum package size for loading through the vertical door. The example chase line on Fig. 4—44 indicates a package 10 inches high by 12 inches wide can be loaded, providing the length does not exceed 158 inches.

The lower forward cargo compartment bottom door (Fig. 4—39) is located at station 456 in the bottom of the fuselage. Figure 4-45 indicates maximum package size for loading through the lower forward cargo compartment bottom door. The example chase line on Fig. 4-45 indicates a package 10 inches high by 24 inches wide can be loaded, providing the length does not exceed 92 inches.

The lower aft cargo compartment door (Fig. 4—39) is located at station 906 in the bottom of the fuselage. Figure 4—46 indicates maximum package size for loading through the lower aft cargo door. The example chase line on Fig. 4—46 indicates a package 24 inches high by 21 inches wide can be loaded, providing the length does not exceed 60.5 inches.

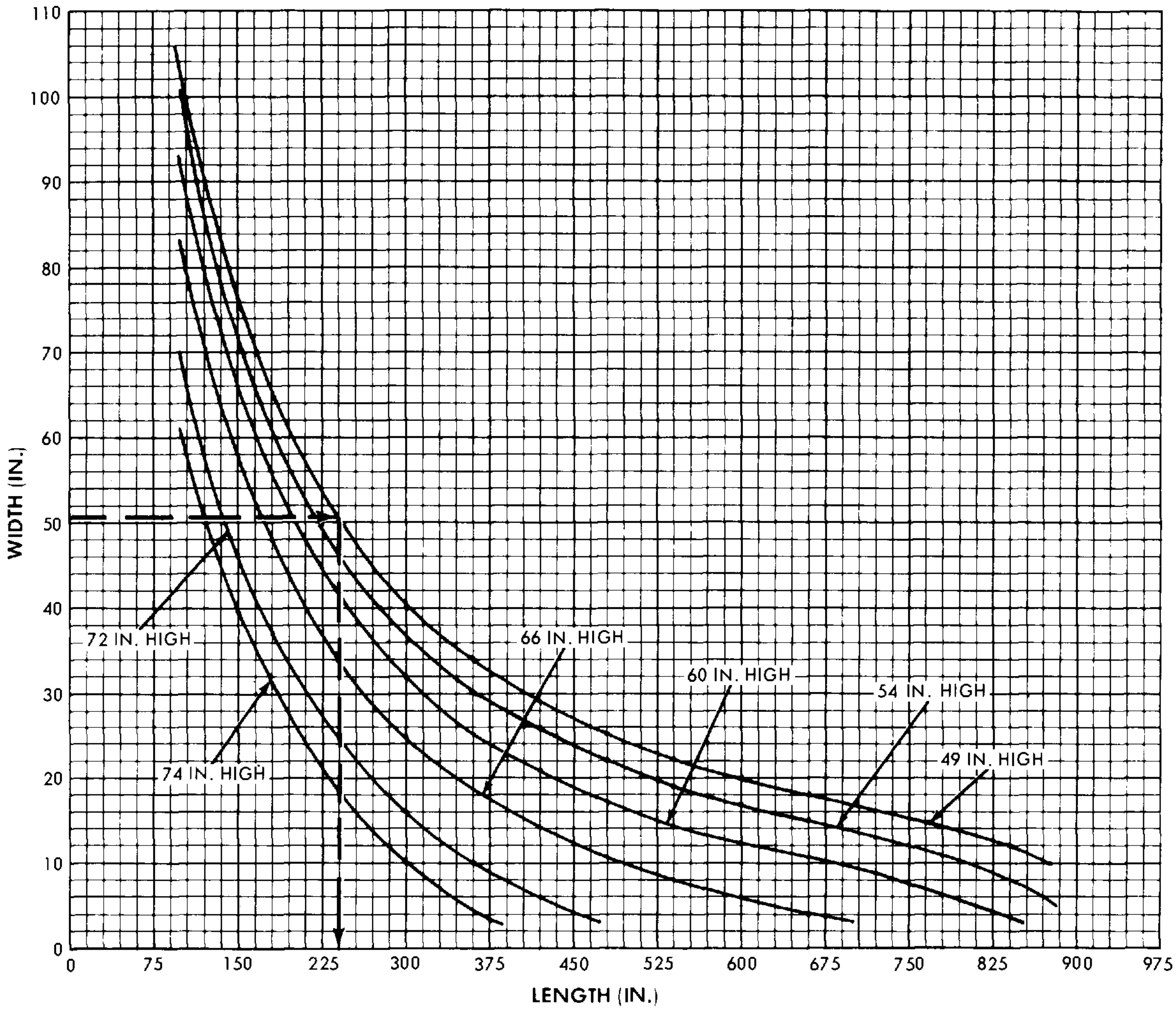


FIGURE 4-42. MAIN CARGO DOOR PACKAGE SIZE GRAPH, C-121/1049H AIRCRAFT

4—34 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-121 1049H aircraft:

Forward	6.0
Aft	1.5
Side	1.5
Vertical	2.0

4—35 CARGO LOADING AND UNLOADING PROVISIONS

The C-121, 1049H aircraft does not have special loading aids. A high-lift truck or fork lift can be used for loading and unloading cargo, provided it has a lift of at least 8.5 feet for the main cargo door and 11.5 feet for the forward cargo door.

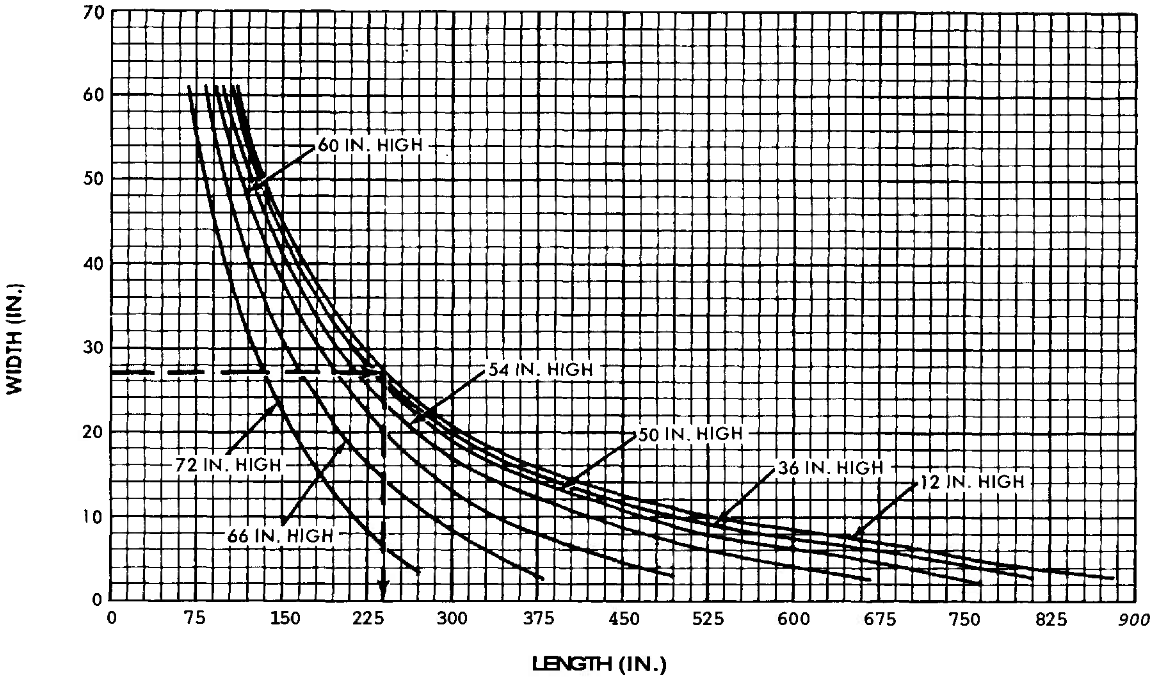


FIGURE 4-43. FORWARD CARGO DOOR PACKAGE SIZE GRAPH, C-121/1049H AIRCRAFT

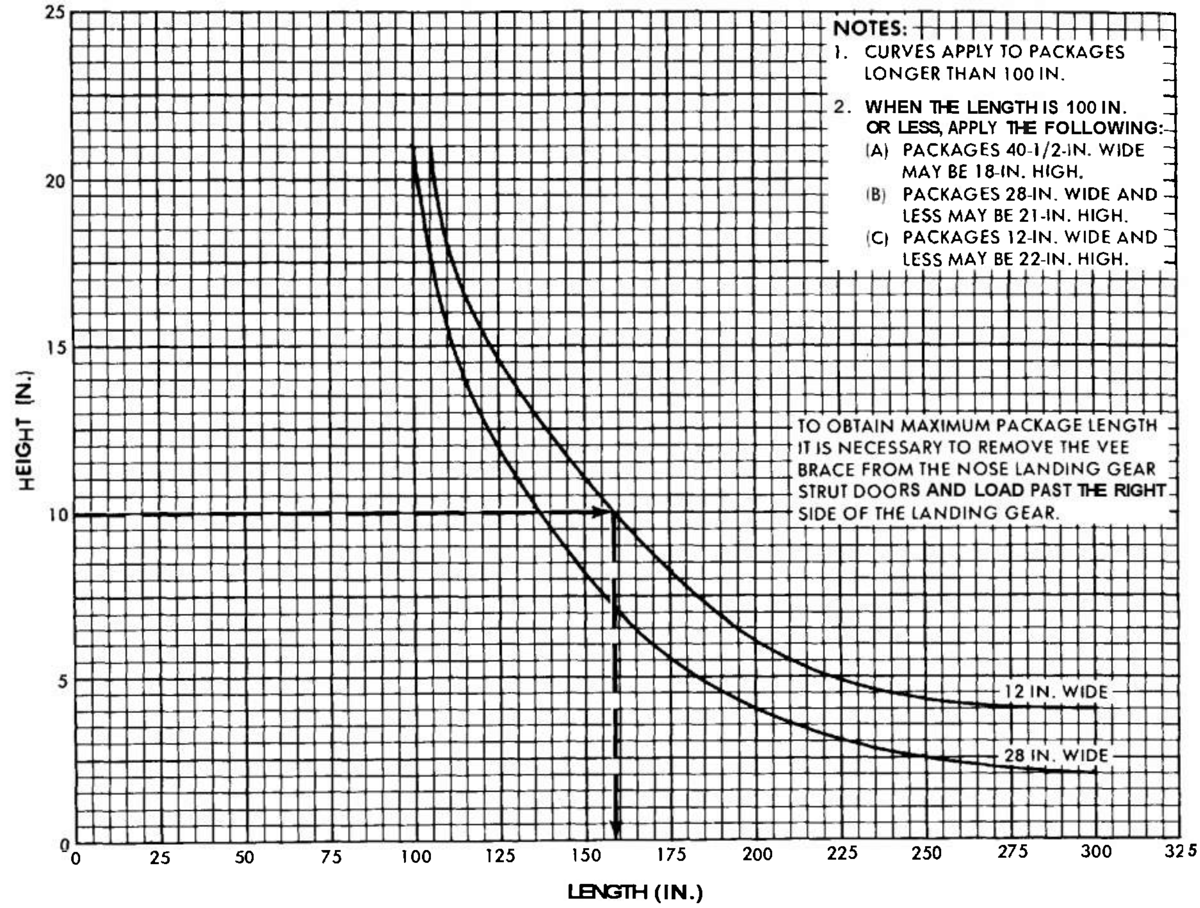


FIGURE 4–44. LOWER FORWARD CARGO COMPARTMENT VERTICAL DOOR PACKAGE SIZE GRAPH, C-121/1049H AIRCRAFT

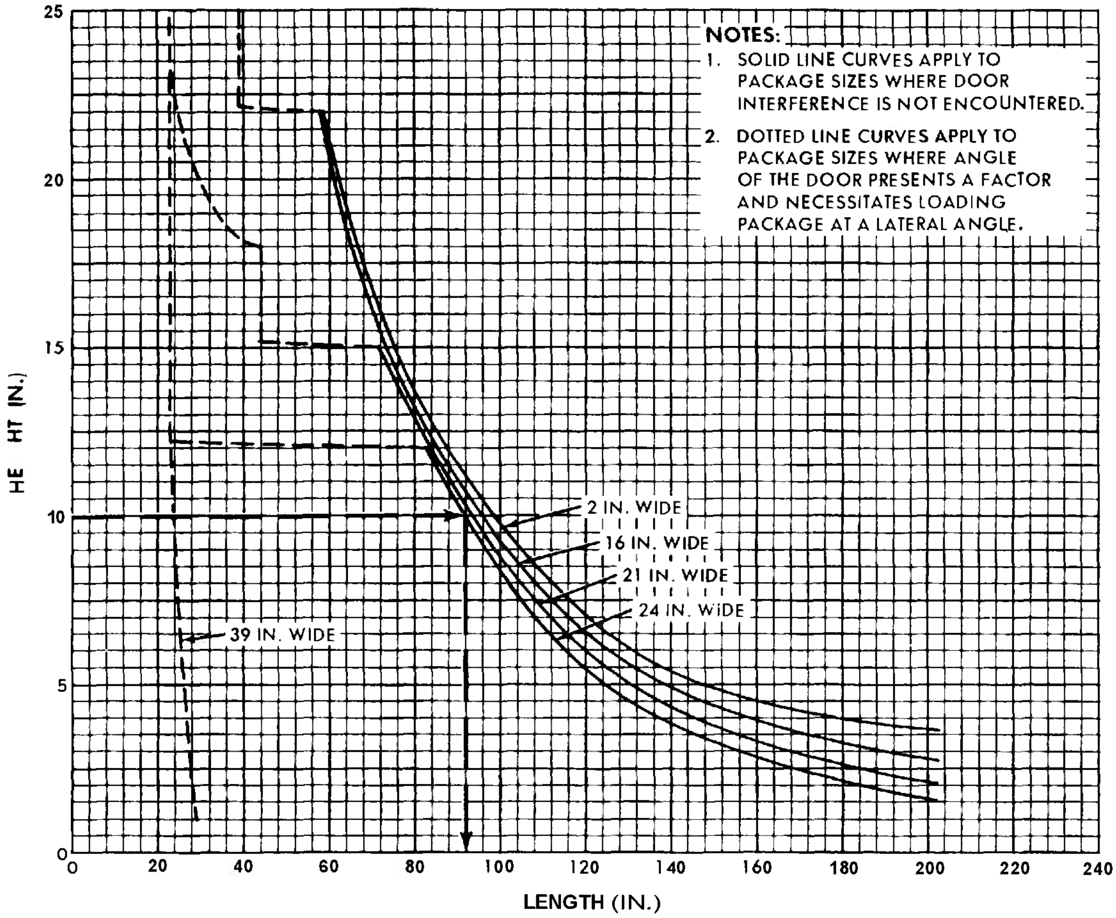


FIGURE 4-45. LOWER FORWARD CARGO COMPARTMENT BOTTOM DOOR PACKAGE SIZE GRAPH, C-121/1049H AIRCRAFT

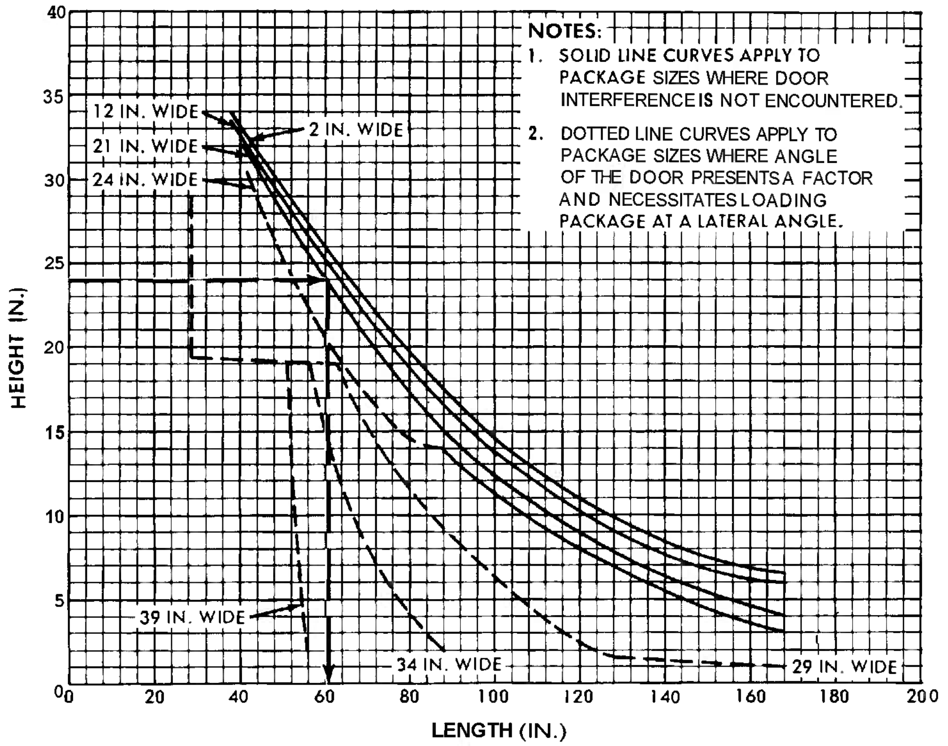


FIGURE 4-46. LOWER AFT CARGO COMPARTMENT DOOR PACKAGE SIZE GRAPH (LOADING FORWARD), C-121/1049H AIRCRAFT

SECTION VIII

C-123

4–36 GENERAL DESCRIPTION

The **C-123** is a twin-engine, medium assault aircraft (Fig. 4-47), especially designed for operating from hastily prepared airfields. It is used primarily as a troop and cargo carrier. Other missions include airdrop, medical evacuation, and parachutist operations. **A** high tail permits heavy equipment to be loaded up an integral ramp which, when raised, completes the aft fuselage structure. The **C-123** is designed to carry payloads up to 20,000 pounds at design gross weight. It has a limited airdrop capability and uses the gravity ejection method. The maximum load that may be extracted is 8000 pounds. Some aircraft are equipped with a pendulum release for use in cargo extraction.

The installation of pod-mounted jet engines which have been ordered for the **C-123** will give the aircraft an extremely short takeoff and landing capability. The jet engines **will** also increase the aircraft's payload under certain tactical conditions.

4-37 CARGO COMPARTMENT

The cargo compartment extends aft from the crew compartment bulkhead (station **120**) to the aft end **of** the cargo ramp (station **564**) (Figs. 4-48 and **4–49**). The usable volume **of** the cargo compartment is **2420** cubic feet. It is basically a rectangular space **444** inches long, **98** inches high, and 110 inches wide at the wheel wells. However, the contour **of** the fuselage, the slope **of** the ramp, and arrangement **of** equipment within the cargo compartment imposes certain limitations on the application of these dimensions.

The length **of** the compartment forward of the ramp is **345** inches. The bailout chute along the right side limits this length

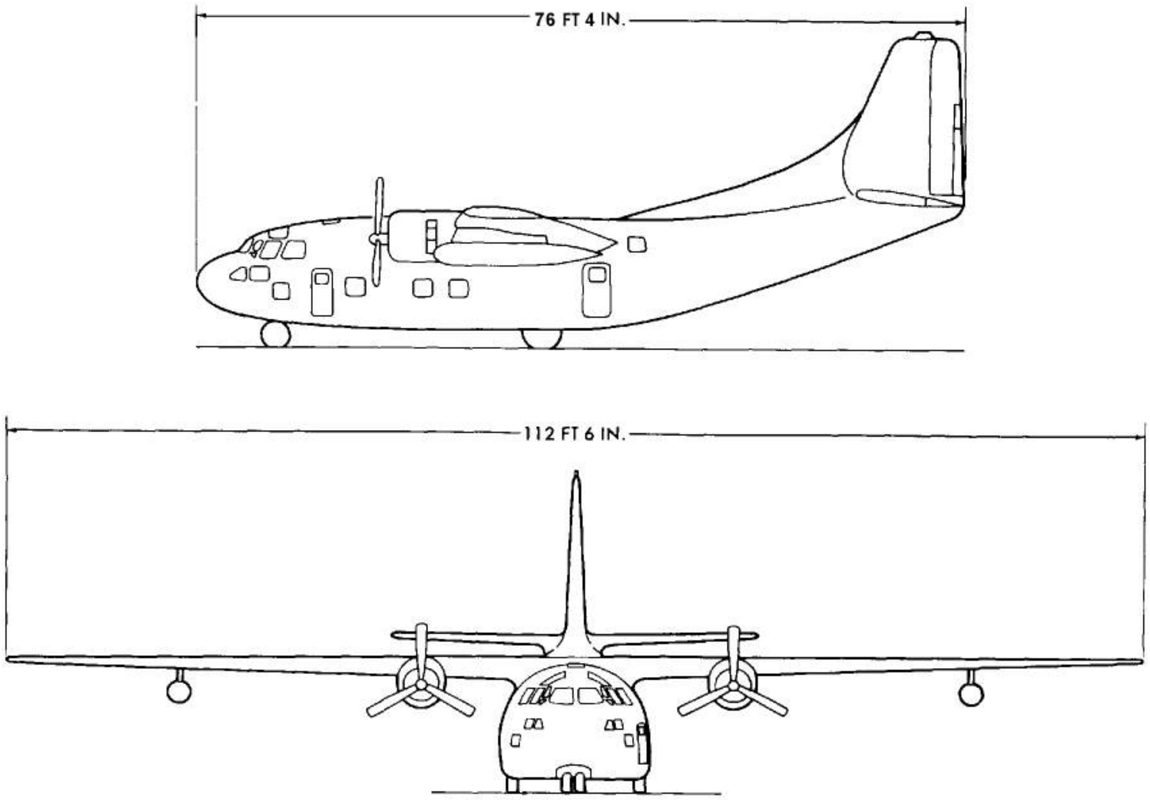


FIGURE 4-47. C-123 AIRCRAFT

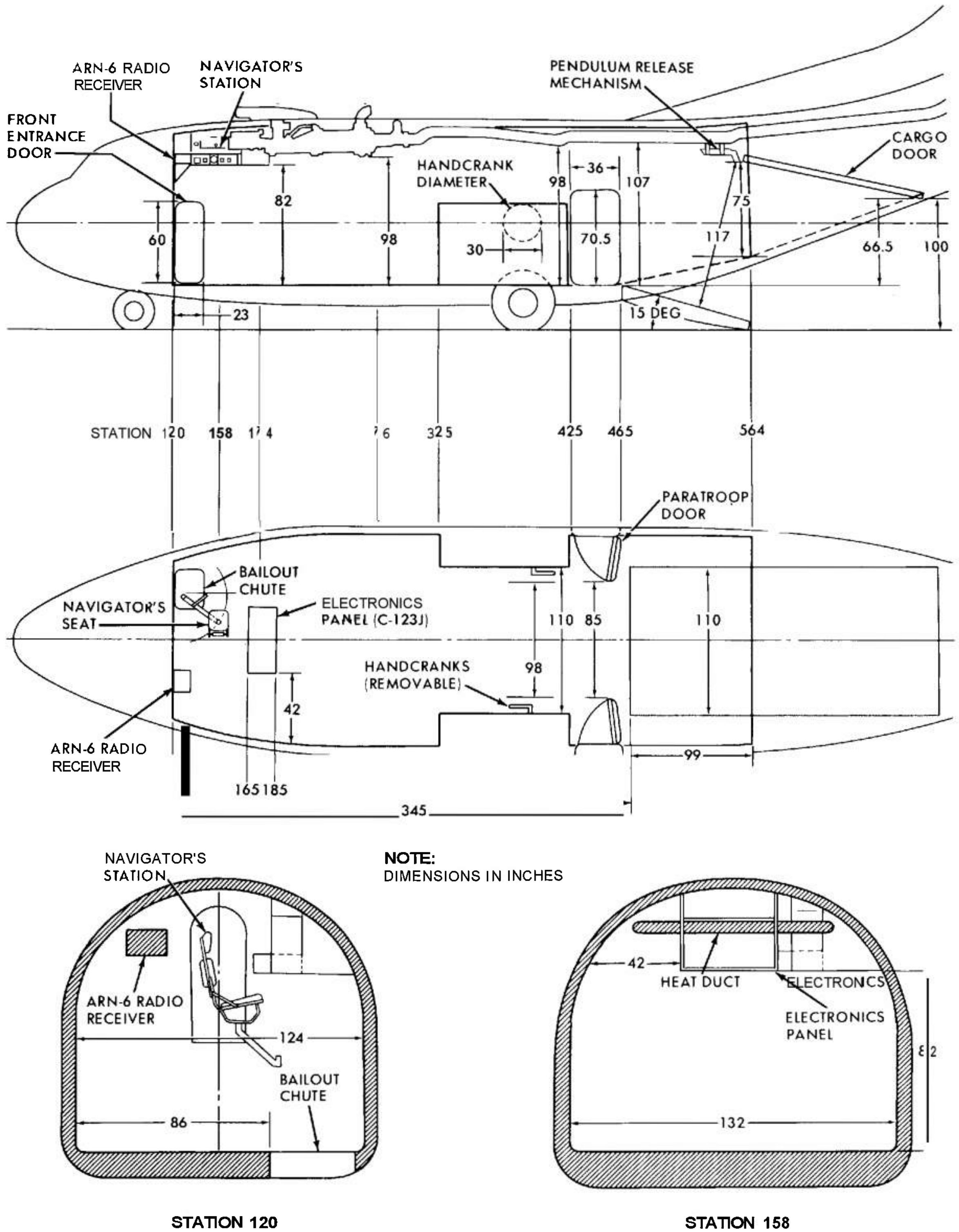


FIGURE 4-48. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-123 AIRCRAFT (AF 54-647, 56-4362, AND SUBSEQUENT) (1 OF 2)

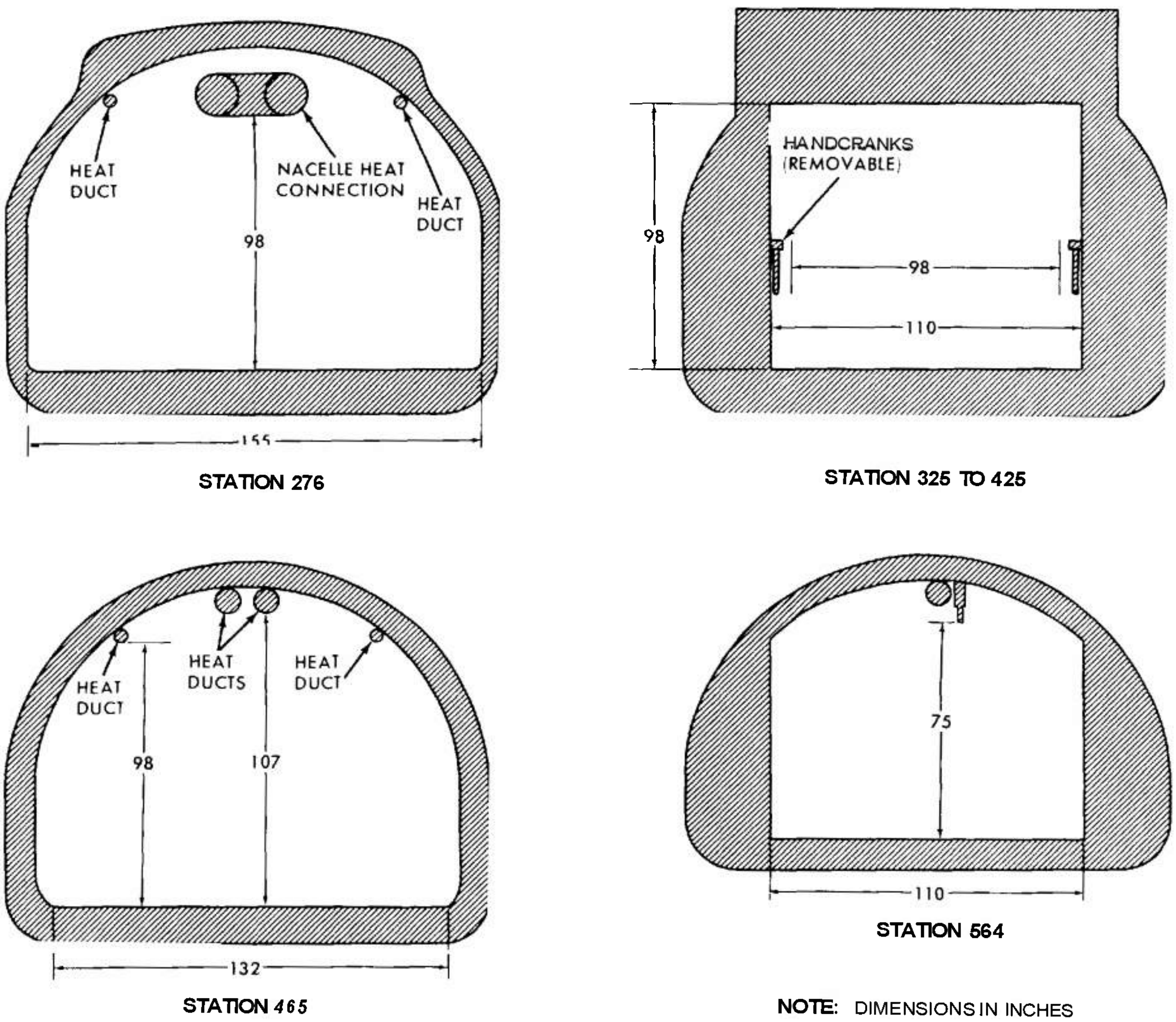


FIGURE 4-48. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-123 AIRCRAFT (AF 54-647, 56-4362, AND SUBSEQUENT) (2 OF 2)

to 320 inches, and on the left side it is limited to 232 inches by the ARN-6 radio receiver. When installed, the navigator's station limits the length to 290 inches on the right side. On C-123J aircraft, the length is reduced to 280 inches by the middle electronic panel.

The width follows the contour of the fuselage forward of the wheel wells. At the bailout chute the width is 86 inches, and at station 305 the width is 156 inches. Between stations 365 and 405, the usable width is 98 inches due to the emergency handcrank. *Aft* of the wheel wells, the paratroop doors, if opened, limit the width to 85 inches; however, these doors will be removed rather than opened when used for parachutist operations.

The height throughout the forward compartment is 98 inches. When installed, the navigator's station limits the height to 82 inches. Installation of roller conveyors will reduce the vertical height 2.5 inches. In the ramp area, the height ranges from 107 inches directly beneath the heating duct to 76 inches at the aft end of the ramp (75 inches on aircraft equipped with the pendulum release mechanism). For airdrop operations, the actual clearance between the cargo floor and the top of the aft cargo opening is 66.5 inches; however, it is possible to extract loads larger in height than

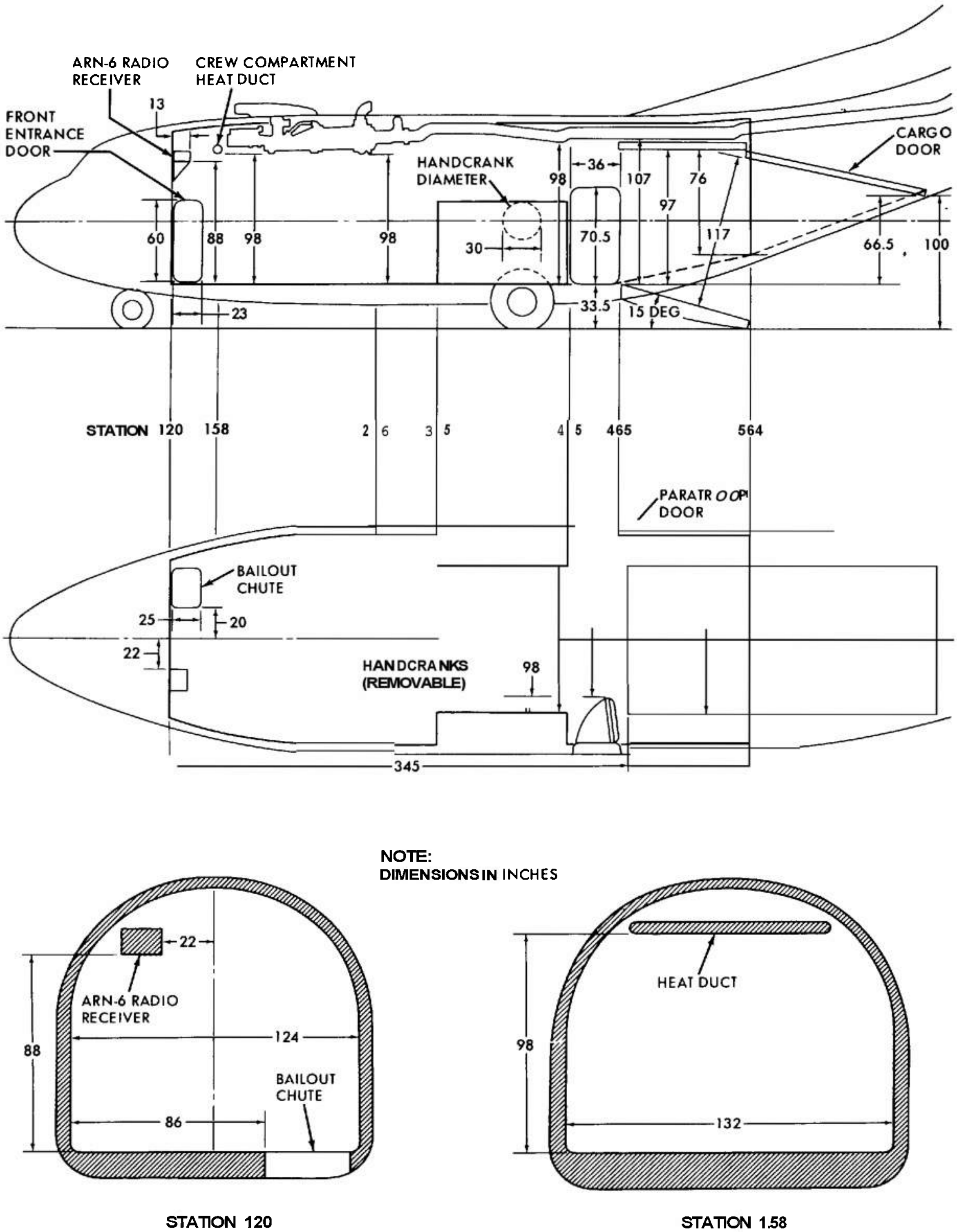


FIGURE 4-49. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-123 AIRCRAFT (AF 54-552 THRU 54-646 AND 54-648 THRU 56-4361) (1 OF 2)

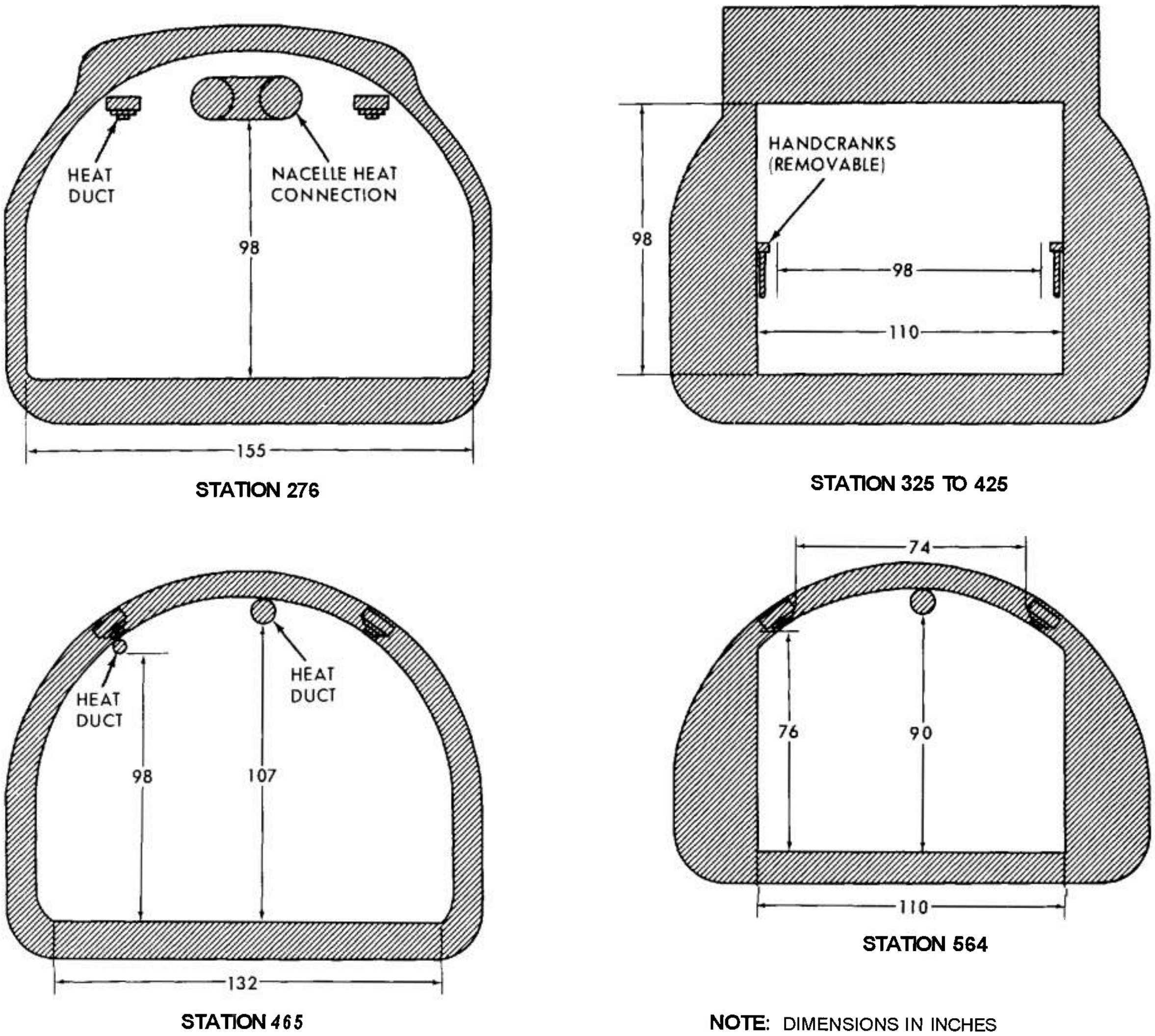


FIGURE 4–49. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-123 AIRCRAFT (AF 54-552 THRU 54-646 AND 54-648 THRU 56-4361) (2 OF 2)

the normal opening by lowering the ramp post to the horizontal position (-10 degrees) and taking advantage of the tipping action of a relatively slow-moving load.

4–37.1 FLOOR LOADING. The permissible loads for the cargo floor and ramp are shown in Fig. 4–50. For distributed loads, the structural capacity of each compartment, C through J, is 7500 pounds, and for compartment K (ramp) the capacity is 3000 pounds. Loads placed in the outer walkway should be at least 30 inches apart, and loads on treadways should be placed 40 inches apart. No loads or obstructions on the bailout chute are permitted during flight. Vehicles with pneumatic tires inflated to 80 psi or less and vehicles having tracks with rubber treads do not require shoring. Vehicles with steel wheels or tracks with cleats, solid rubber, or combat-type tires require shoring.

4–37.2 ANCHORING ARRANGEMENT. Location and rating of the tiedown fittings are shown in Fig. 4–51. Permanently installed tiedown rings are located along the wheel wells. The remaining fittings are removable. Some aircraft have fittings installed forward of the bailout chute at station 121.

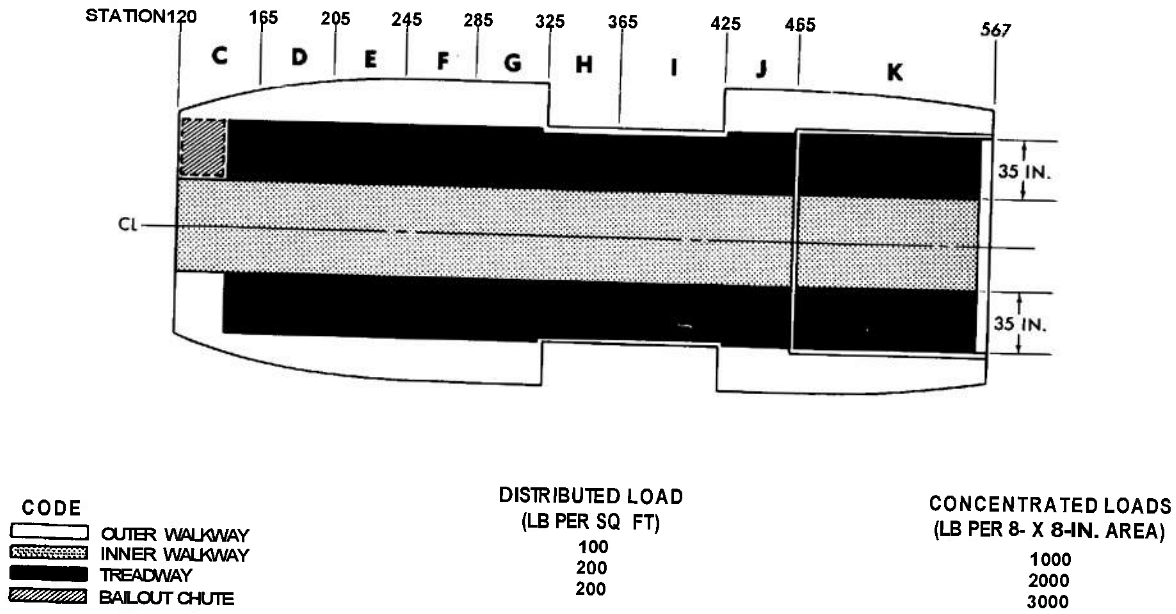


FIGURE 4-50. CARGO COMPARTMENT WEIGHT LIMITS, C-123 AIRCRAFT

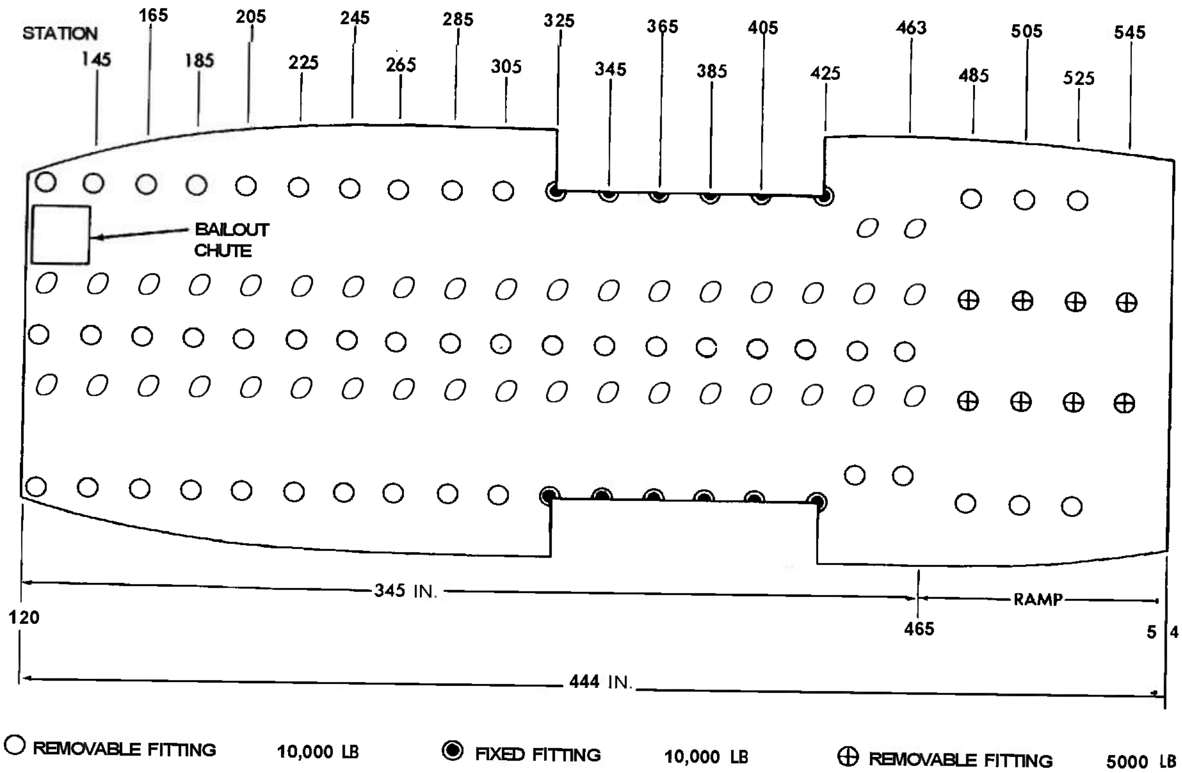


FIGURE 4-51. ANCHORING ARRANCEMENT, C-123 AIRCRAFT

These fittings should not be used, since their use will result in obstruction to the bailout chute.

4-38 CARGO DOOR AND RAMP

The cargo door and ramp, when closed, fair-in the lower aft portion of the fuselage. The cargo door is hinged at the aft end and opens into the fuselage, providing a ground clearance of 100 inches. The ramp is hinged at the forward end. When closed, it is approximately 13 degrees above horizontal, and when fully lowered, it is 15 degrees below the horizontal position. It may be stopped at any intermediate position. The width of both door and ramp is 110 inches. When the ramp and door are fully open, the clearance between the ramp and the forward end of the door is 117 inches. The maximum heights for various lengths and widths of cargo that can be loaded into the C-123 are shown in Fig. 4—52. For example, a crate 140 inches long and 84 inches high has a maximum permissible height of 89 inches. In **Fig.** 4—52, the length notation is based on the assumption that no cargo will be loaded forward of station 145, in order to assure adequate clearance for crew exit via the bailout chute.

4-39 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-123 aircraft:

Forward	8.0
Aft	2.0
Side	1.5
Vertical	4.5

4-40 CARGO LOADING AND UNLOADING PROVISIONS

Loading and unloading provisions include auxiliary ramps and a load assist pulley. The auxiliary ramps are for use when vehicles require a more gradual slope than that provided by the ramp. They are approximately of the same slope as the ramp and are attached to the ramp with hooks.

A load assist pulley is attached to the floor at the forward end of the cargo compartment for winching. When the motivating force is placed at the rear of the aircraft, the maximum permissible draw bar pull is 3300 pounds, equivalent to towing a 13,500-pound wheeled vehicle up the ramp. If the cable is routed out the front entrance door, the maximum permissible pulling force is 2800 pounds, equivalent to towing a 11,300-pound wheeled vehicle up the ramp.

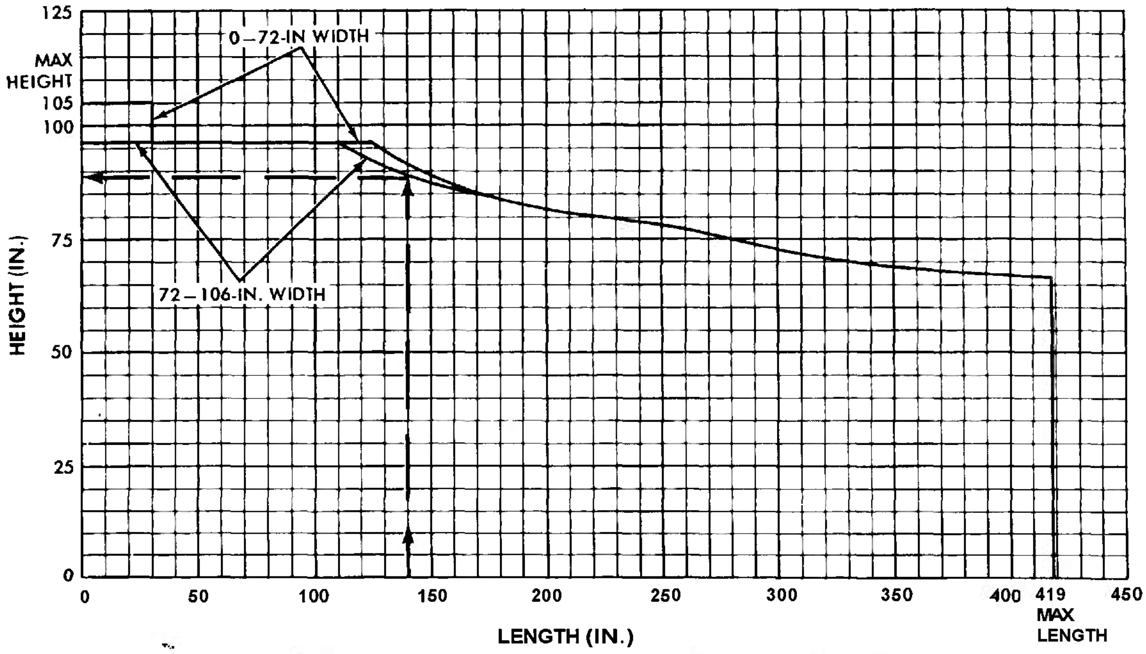


FIGURE 4—52. CARGO DOOR PACKAGE SIZE GRAPH, C–123 AIRCRAFT

SECTION IX

C-124

4—41 GENERAL DESCRIPTION

The C-124 is a four-engine, long-range, heavy transport (Fig. 4—53). Its principal mission is airlifting personnel and cargo. It is designed to carry a maximum cargo load of approximately 50,000 pounds, and has a maximum capacity of 10,000 cubic feet. The C-124 features a clamshell-type door in the nose which permits straight-in loading, and an auxiliary folding floor for increased deck area. A loading well platform is provided to work in conjunction with two traversing traveling crane hoists capable of lifting 16,000 pounds with the installation of snatch blocks. Airdrop of A-22 containers is also accomplished through the loading well.

A 2 CARGO COMPARTMENT

The cargo compartment extends from station 236 to station 1120. Critical dimensions and contours are shown in Fig. 4—54. From station 236 to station 363 the floor slopes up as a continuation of the pose loading ramps at an angle of 17 degrees. At station 363 the floor angle is reduced to 11 degrees, 34 minutes and continues to station 460. From station 460 to station 1120 the floor is nearly level. The auxiliary floor is hinged to the fuselage and is supported by stanchions attached to the main cargo floor. The auxiliary floor is constructed in sections which may be used independently of each other. In the event vertical clearance presents a problem in

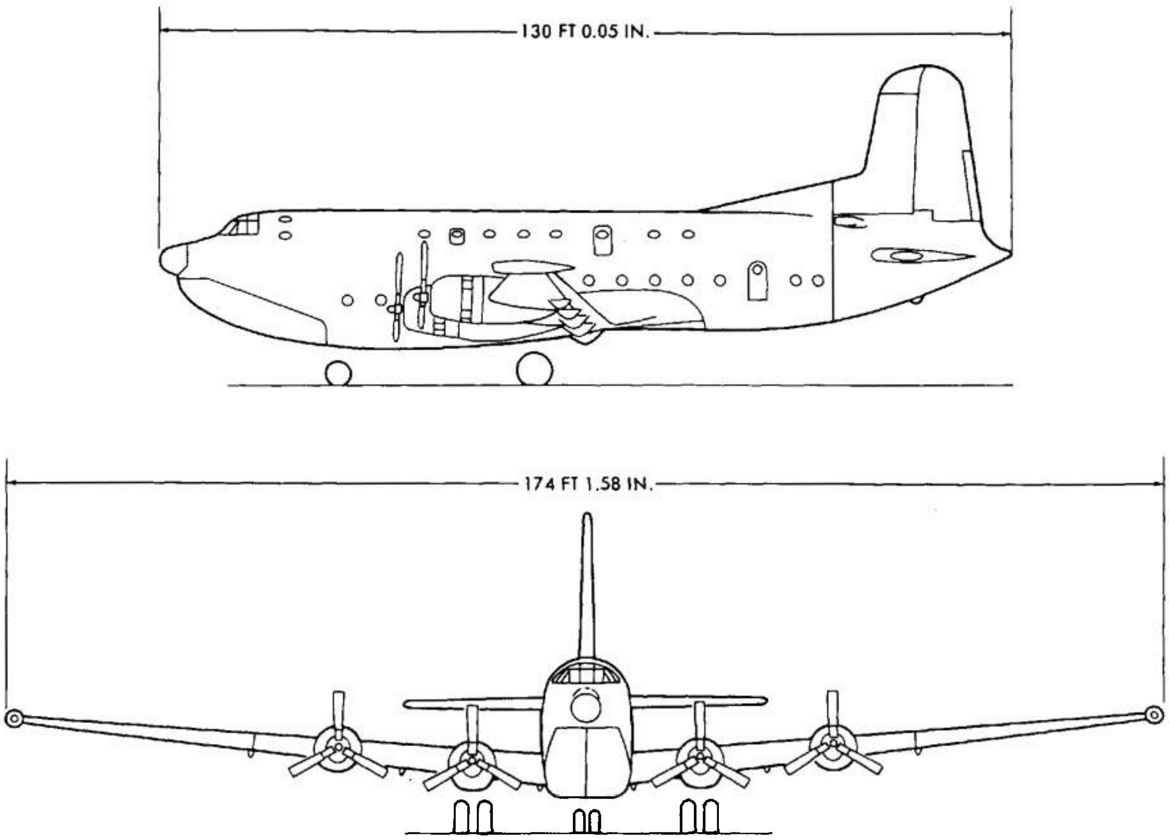
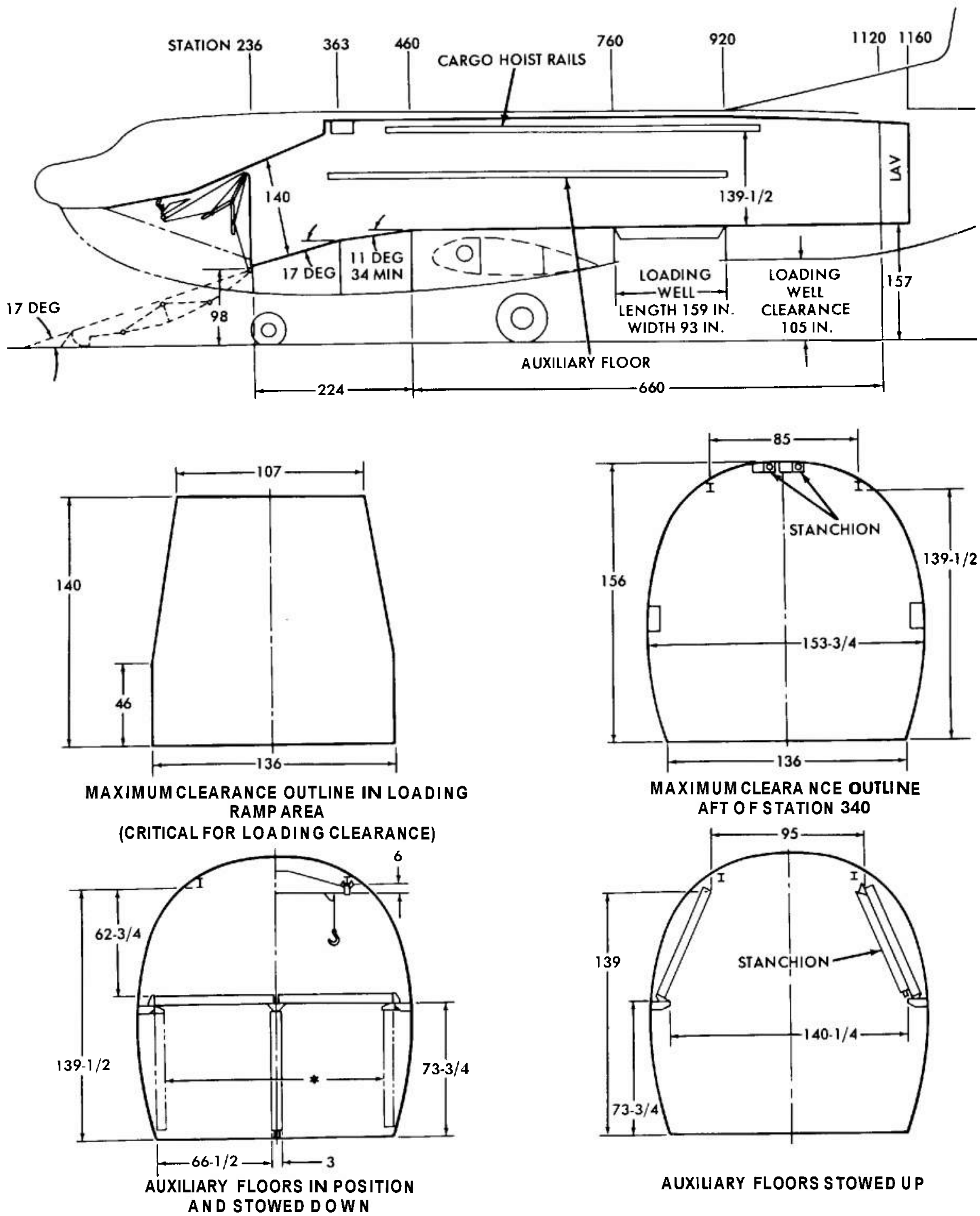


FIGURE 4—53. C-124 AIRCRAFT



* 125 IN. STA 340 – 540 (AF 49-232)– AF 49-250)
131 IN. STA 540 – 1020(AF 49-232) – AF 49-250)
131 IN. ALL STATIONS (AF 49-251 AND SUBQ)

NOTE:
DIMENSIONS IN INCHES

FIGURE 4–54. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-124 AIRCRAFT loading certain items of cargo, the auxiliary floor may be removed completely.

4–42.1 FLOOR LOADING. The main cargo floor is designed for a uniformly distributed load of 183 pounds per square foot, and the auxiliary floor is designed for a uniformly distributed load of 43 pounds per square foot. The maximum single-axle load on the treadways and maneuvering areas is ***20,000*** pounds. Normally, only compartments C through K are used for general cargo (Fig. 4–55). Maximum concentrated capacities on treadways of these compartments are shown in Fig. 4–55; however, the loading of adjacent compartments to their maximum rated capacity is restricted, dictated by the strength of the aircraft structure. The manner in which adjacent compartments are loaded is controlled by grouping the compartments into three zones: compartments C, D, and E are in zone 1 with an allowable load of 29,000 pounds; F is in zone 2 with an allowable load of **40,000** pounds; and G, H, I, J, and K are in zone 3 with an allowable load of 33,000 pounds.

4–42.2 ANCHORING ARRANGEMENT. Two types of cargo tiedown fittings are installed in the aircraft. The locations and ratings of the heavy cargo tiedown fittings are shown in Fig. 4–55. The fittings on the extreme outboard sides of the floor have clevis-type rings. Two sizes of rings are stowed in zipper bags and installed as needed. One is a 3/4-inch threaded trunnion and the other is a 1-1/8-inch threaded trunnion.

A 3 CARGO DOORS AND RAMPS

4–43.1 NOSE LOADING DOORS AND RAMPS. The nose loading doors consist of two outward-opening, clamshell-type doors which form the lower forward portion of the fuselage. These doors enclose the retractable nose loading ramps. The ramps consist of two separate, laterally adjustable, 36-inch wide ramps, which form a 17-degree angle or 30-percent slope with the ground. The ramps may be positioned to a minimum of 24 inches apart and a maximum of 50 inches apart, measured from inside edge to inside edge. When extended, the ramps measure approximately 336 inches from station 236 to the ramp toe tips. The ramps are capable of supporting 50,000 pounds. They have a single-axle load limit restriction of 20,000 pounds.

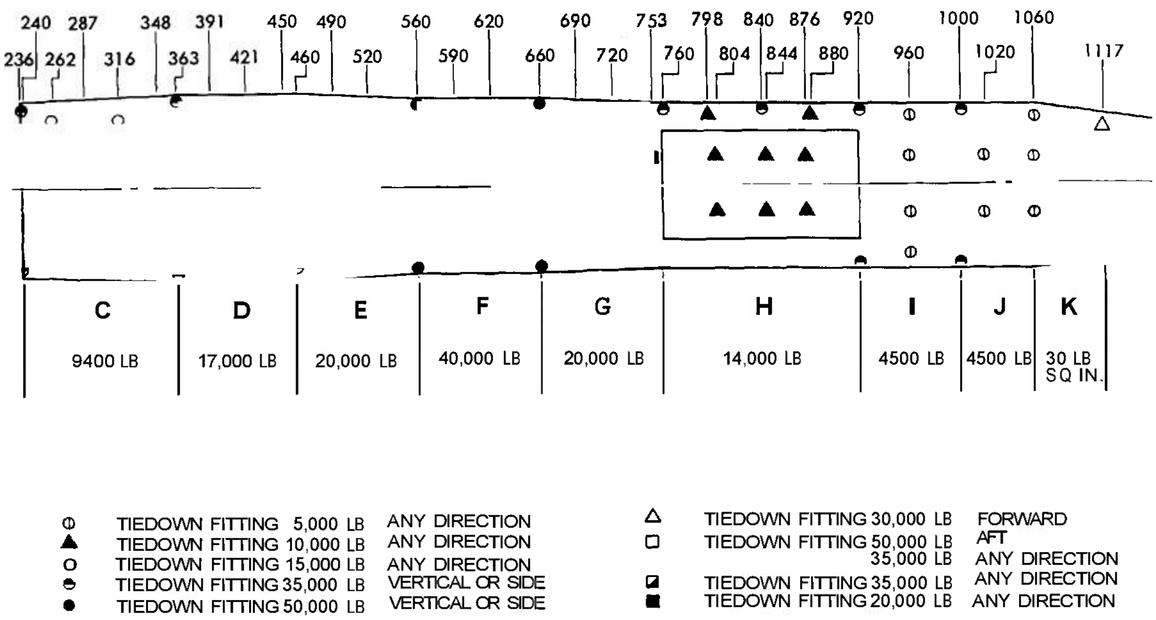


FIGURE 4–55. CARGO COMPARTMENT WEIGHT LIMITS AND ANCHORING ARRANGEMENT, C-124 AIRCRAFT

Due to the rather sharp ramp angle, the overall unit length and unit height of cargo loads are critical factors. Ground clearance is another problem which must be considered. If the wheel base of a vehicle is such that it might come in contact with the ramp crest, steps must be taken to raise either the forward or aft end of the vehicle. The maximum clearance outlined in the loading ramp area is shown in Fig. 4—54.

Figure 4—56 shows maximum allowable height of a vehicle at various widths. It also indicates the maximum allowable overhang (front or rear) from axle centerlines. For example, a vehicle 120 inches wide, with an overhang of 75 inches, would have a maximum allowable height of 87 inches.

Figure 4—57 shows the minimum ground clearance required to clear the ramp crest at various vehicle wheelbase lengths. For example, a vehicle with a wheelbase of 300 inches would have a minimum allowable ground clearance of 21 inches.

Figure 4—58 shows the minimum ground clearance required at various vehicle overhang dimensions. For example, a vehicle with an overhang of 70 inches would have a minimum allowable ground clearance of 21 inches.

Figure 4—59 charts the various cargo sizes in height, length, and width of rectangular-crated cargo that may be loaded through the nose loading door. For example, a crate 480 inches long by 119 inches wide would have a maximum permissible height of 87 inches.

4—43.2 LOWER CARGO DOORS AND LOADING WELL PLATFORM. The lower cargo doors are located between stations 760 and 920 and consist of two outward-opening, contoured doors that enclose the loading well. The

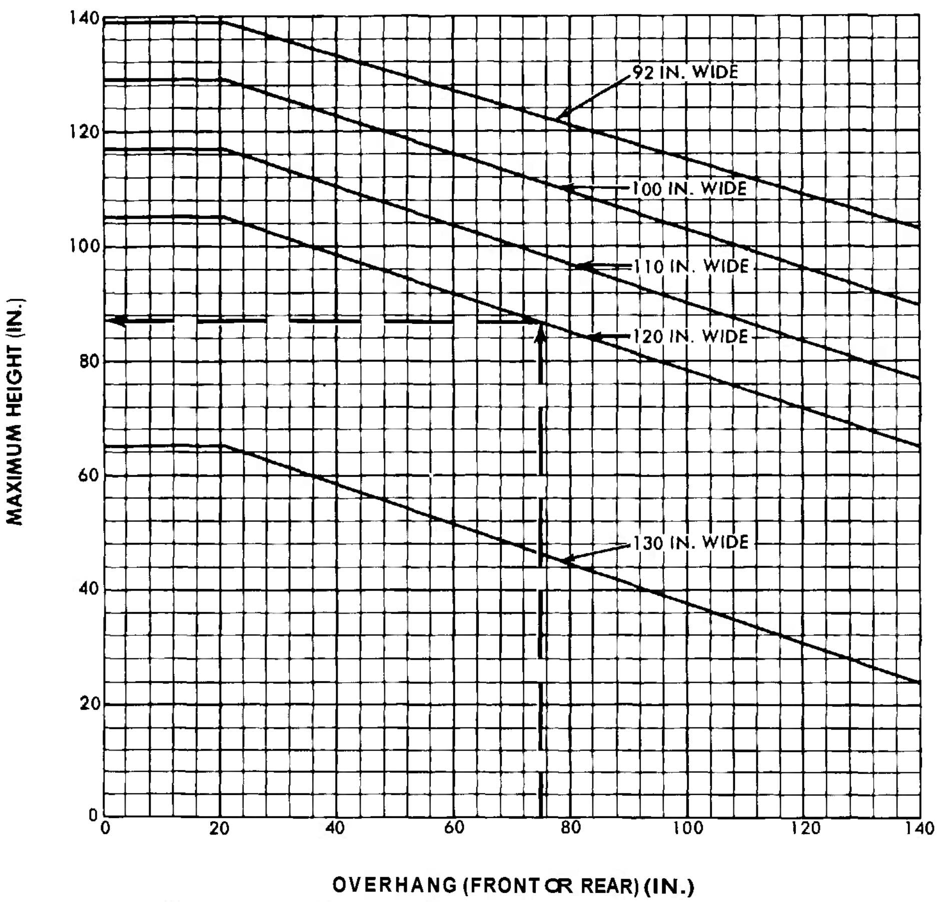


FIGURE 4-56. NOSE LOADING AREA CLEARANCE (HEIGHT), C-724 AIRCRAFT

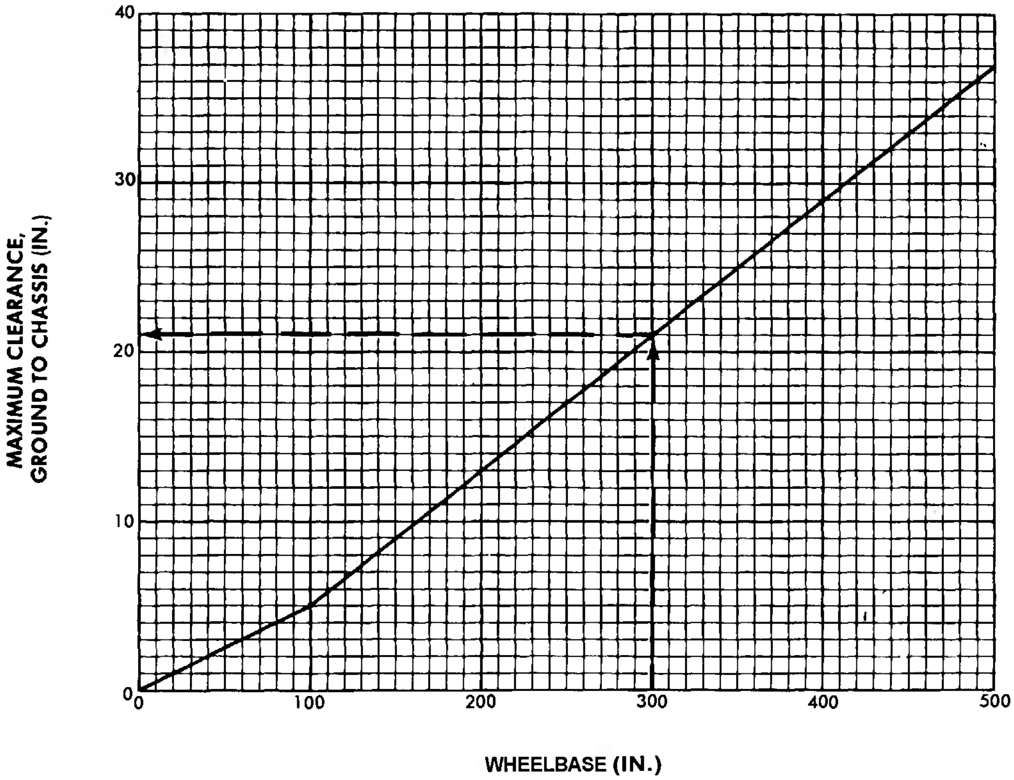


FIGURE 4-57. NOSE LOADING AREA CLEARANCE (RAMP CREST), C-124 AIRCRAFT

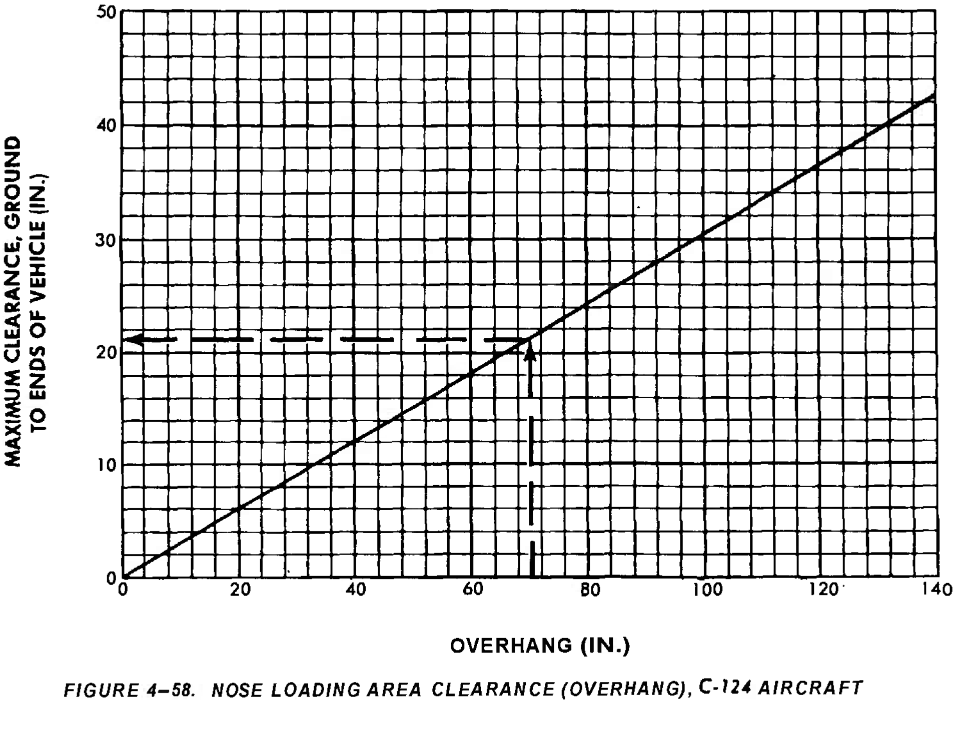


FIGURE 4-58. NOSE LOADING AREA CLEARANCE (OVERHANG), C-124 AIRCRAFT

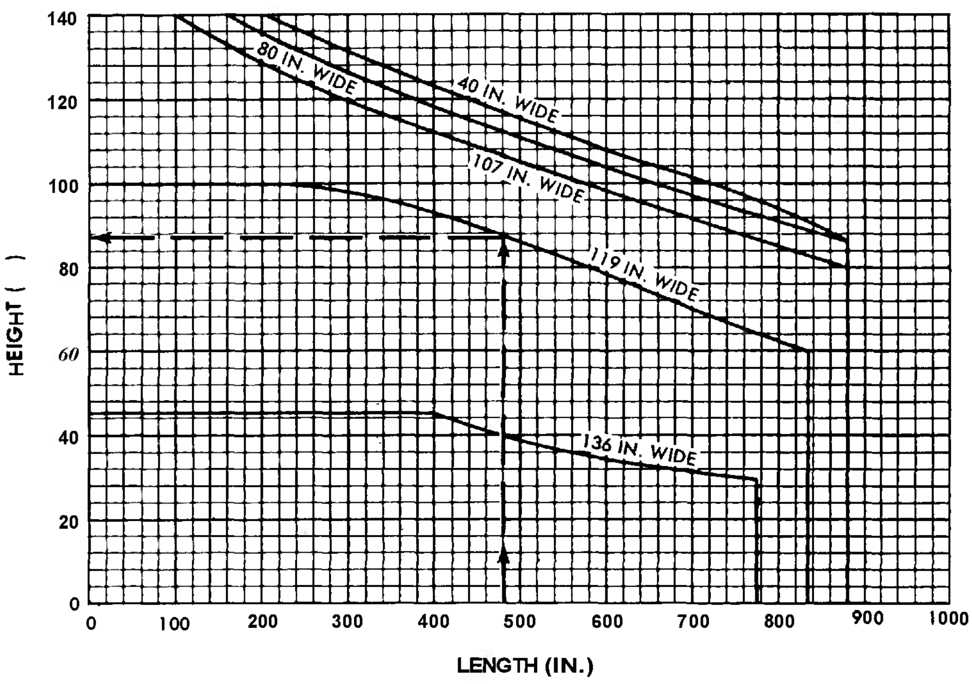


FIGURE 4-59. NOSE LOADING DOOR RECTANGULAR-CRATED CARGO SIZE LIMITS, C-124 AIRCRAFT

loading well platform forms the cargo floor over the top of the loading well. The platform measures approximately 155 inches long by 89 inches wide (Fig. **4—60).** It is capable of supporting a maximum load of **9300** pounds. The traveling cranes serve as the elevator mechanism for all operations involving the platform.

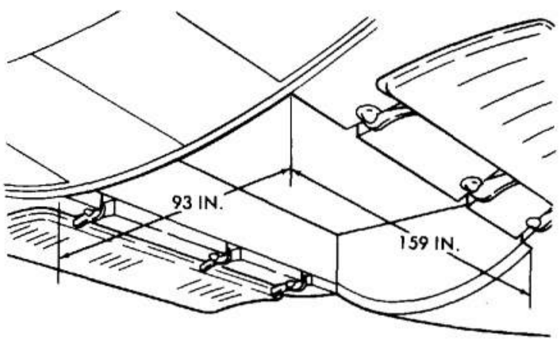
4—44 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the **C-124** aircraft:

Forward	**3.0**
Aft	**1.5**
Side	1.5
Vertical	2.0

4—45 CARGO LOADING AND UNLOADING PROVISIONS

In addition to the nose loading ramps and the loading well platform, two traveling cranes and two winch cable pulleys are provided in the aircraft *to* aid in loading and unloading cargo. Each of the two cranes



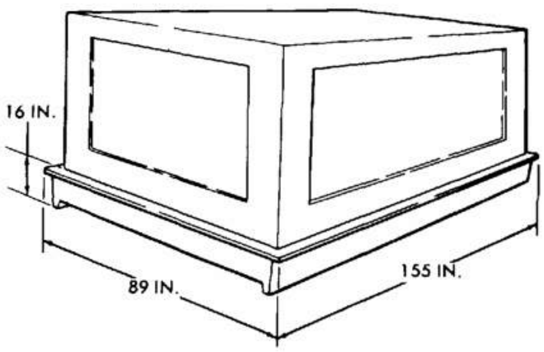


FIGURE 4—60. LOADING WELL CLEARANCE, C-124 AIRCRAFT

is equipped with two hoist cables. The maximum allowable load that each cable is capable of hoisting unassisted is 2000 pounds. With the installation of snatch blocks, the maximum may be increased to 16,000 pounds when both traveling cranes are used.

The winch cable pulleys are installed at station 1117. The pulleys are designed to be used with a 3/4-inch cable attached to an external winch with a maximum capacity of 30,000 pounds.

SECTION X

C-130/382B

4–46 GENERAL DESCRIPTION

The C-130/382B is a four-engine, turboprop, medium-assault transport (Fig. 4-61). There are four military models of this aircraft used for cargo transport, parachutist operations, and airdrop: C-130A, C-130B, C-130D, and C-130E. The C-130 commercial counterpart, the Lockheed 382B, can be used for air transport of cargo. Special features of the C-130/382B aircraft are cargo compartment pressurization, ground and inflight air conditioning, and an upswept aft fuselage which contains a built-in loading ramp that serves as the rear door. C-130 aircraft are equipped with the AF/A32H-1A or the A/A32H-4 dual-rail cargo handling system. Some C-130 aircraft may be equipped with the skate wheel and buffer board system; however, this system is being replaced with the dual-rail system on all C-130 aircraft. The C-130D is equipped with skis for arctic operation. The 382B aircraft is equipped with conveyors which can be varied to accommodate 118-inch and 108-inch wide pallets.

A 7 CARGO COMPARTMENT

The cargo compartment of the C-130/382B provides a cargo space 492 inches long, 123 inches wide between the inner walls of the main wheel wells, and 108 inches high (109 inches high on the 382B) at the lowest point under the wing center section (Fig. 4—62). The height may be increased to 109 inches on the C-130 by removing the litter stanchion bracket from the bottom of the center wing box beam. Some items longer than 492 inches may be carried if they are constructed so that part of the item can extend above the sloping ramp. The top of the cargo compartment is 600 inches long.

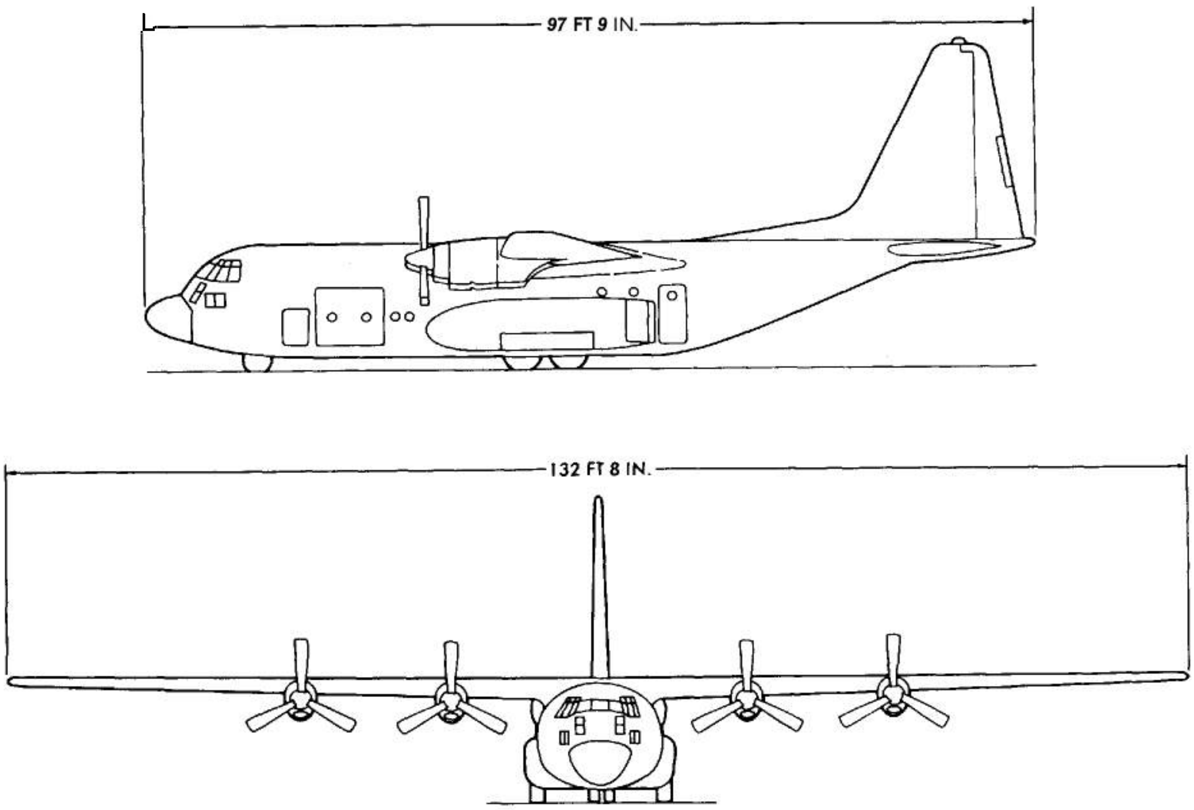
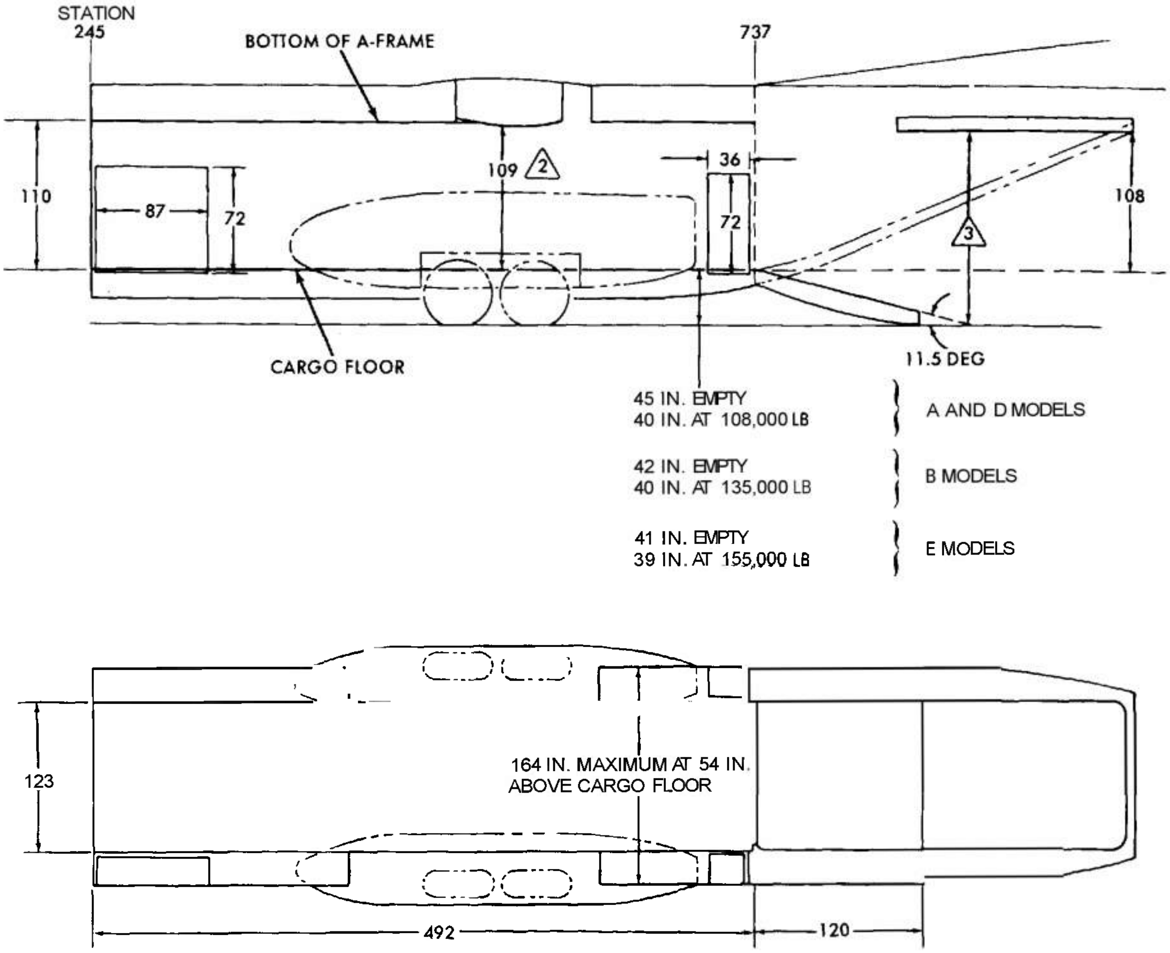


FIGURE 4–61. C-130/382B AIRCRAFT



NOTE:
1 DIMENSIONS IN INCHES.
2 108 IN. WITH LITTER BRACKET INSTALLED.
WITH DUAL-RAIL AIRDROP SYSTEM INSTALLED DEDUCT 2.625 IN.
3 AIRCRAFT ON HARD SURFACE, LANDING GEAR STRUTS AT STANDARD INFLATION, NOMINAL DIAMETER TIRES AT 35 PERCENT DEFLECTION, THIS DISTANCE IS:

C-130A AND D: 146 IN. AT 108,000 LB.
C-130B: 147 IN. AT 135,000 LB.
3826 AND C-130E: 143 IN. AT 155,000 LB.

FIGURE 4-62. CARGO COMPARTMENT DIMENSIONS, C-130/382B AIRCRAFT

The maximum approved load that may be extracted from the C-130 during airdrop operations is **25,000** pounds. Loads up to 35,000 pounds may be extracted with special approval. Loads are extracted from the aft end utilizing the dual-rail system and extraction parachutes to supply the extraction force.

4-47.1 FLOOR LOADING. The cargo floor and ramp are designed to withstand a vehicle load from pneumatic tires with 100-psi internal tire pressure, a bulk cargo load of **50** psi, or a vehicle load on hard tires of 500 pounds per inch of tire width. On some C-130 aircraft, 21-inch treadways are installed 58 inches apart; other C-130 aircraft, and all 382B aircraft, have 35-inch treadways 30 inches apart. During loading operations, loads on the treadways must not exceed 13,000 pounds per axle or **6500** pounds per wheel. During flight, loads on the treadways forward of station 337 and aft of station 682 must not exceed 6000 pounds per axle. Between stations 337 and 682, the treadways will withstand 13,000 pounds per axle. Outside the treadways, the load must not exceed 5000 pounds per axle. Any load placed on the ramp for flight must not exceed 125 pounds per square foot and **500** pounds per running foot.

Flight limits of palletized cargo on the C-130 dual-rail system are:

a. Stations 245 to 337 — 2800 pounds per linear foot.

b. Stations 337 to 682 — 3200 pounds per linear foot.

c. Stations 682 to 737 — 2800 pounds per linear foot.

d. Stations 737 to **858** — 1000 pounds per linear foot.

Flight limits of palletized cargo on the 382B conveyors are:

a. Stations 245 to 737 — 2600 pounds per linear foot.

b. Stations 737 to **869** — 1000 pounds per linear foot.

Maximum individual compartment capacities are shown in Fig. 4—63.

4—47.2 ANCHORING ARRANGEMENT. Recessed 10,000-pound tiedown fittings are set into a symmetrical pattern 20 inches apart in the cargo floor. Fittings of 25,000-pound capacity are arranged around the edges of the cargo floor. Fittings of 5000-pound capacity are set in the floor of the ramp and along the sides of the cargo compartment. Locations and ratings of the fittings are shown in Fig. 4-64.

A 8 CARGO DOORS AND RAMPS

4—48.1 AFT CARGO DOOR AND RAMP. The aft cargo door and ramp, when closed, fairs-in the lower aft portion of the fuselage. The cargo door is hinged at its aft end and opens upward and inward. The clear opening provided by the door and ramp is between 115 and 117-1/4 inches wide and 104-3/4 and 108 inches high, depending upon various equipment installations. When lowered, the ramp forms an angle of 11.5 degrees with the ground. When closed, it forms an angle of 159 degrees with the cargo floor. The ramp may be locked in a horizontal position with the cargo floor. Treadways on the ramp will withstand the same loads as treadways on the cargo floor.

4—48.2 FORWARD CARGO DOOR. On some C-130 aircraft, a forward cargo door provides an opening 87 inches wide by 72 inches high (Fig. 4—62). 382B and late production C-130E aircraft do not have a forward cargo door. On C-130 aircraft incorporating a forward cargo door, it is located on the left side of the fuselage, aft of the crew door. The door is hinged across the top, and is opened outward by two hydraulic cylinders. The maximum lengths for various widths of 72-inch cargo that can be loaded through the forward cargo door are shown in Fig. 4—65. For example, a crate 48 inches wide can be loaded provided its length does not exceed 200 inches.

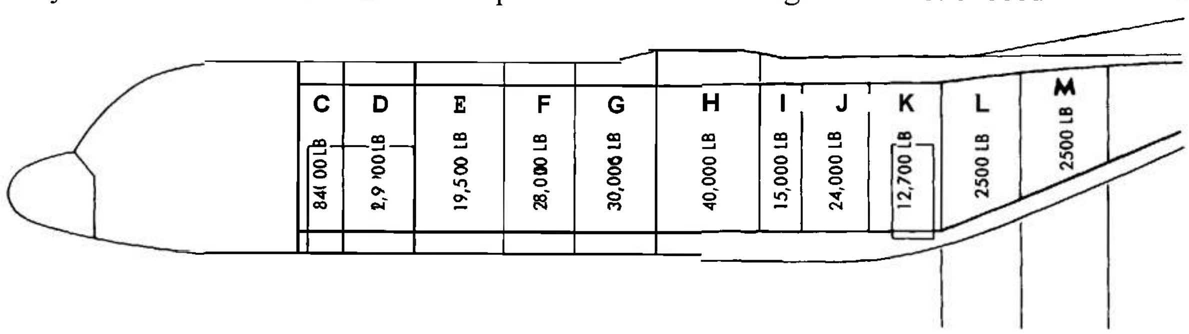


FIGURE 4-63. CARGO COMPARTMENT WEIGHT LIMITS, C-130/382B AIRCRAFT

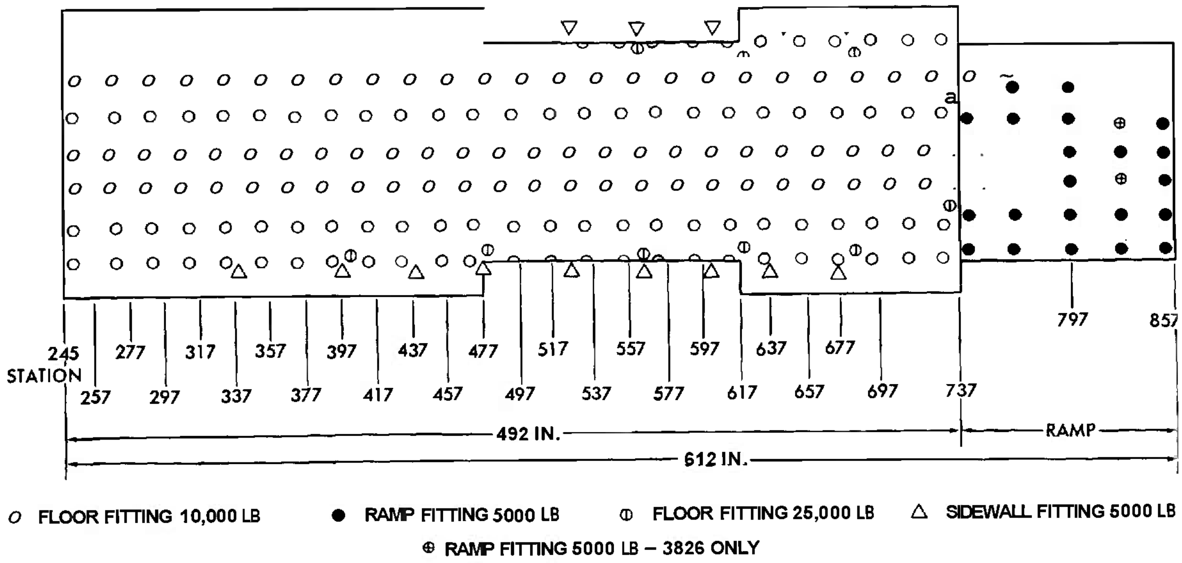


FIGURE 4-64. ANCHORING ARRANGEMENT, C-130/382B AIRCRAFT

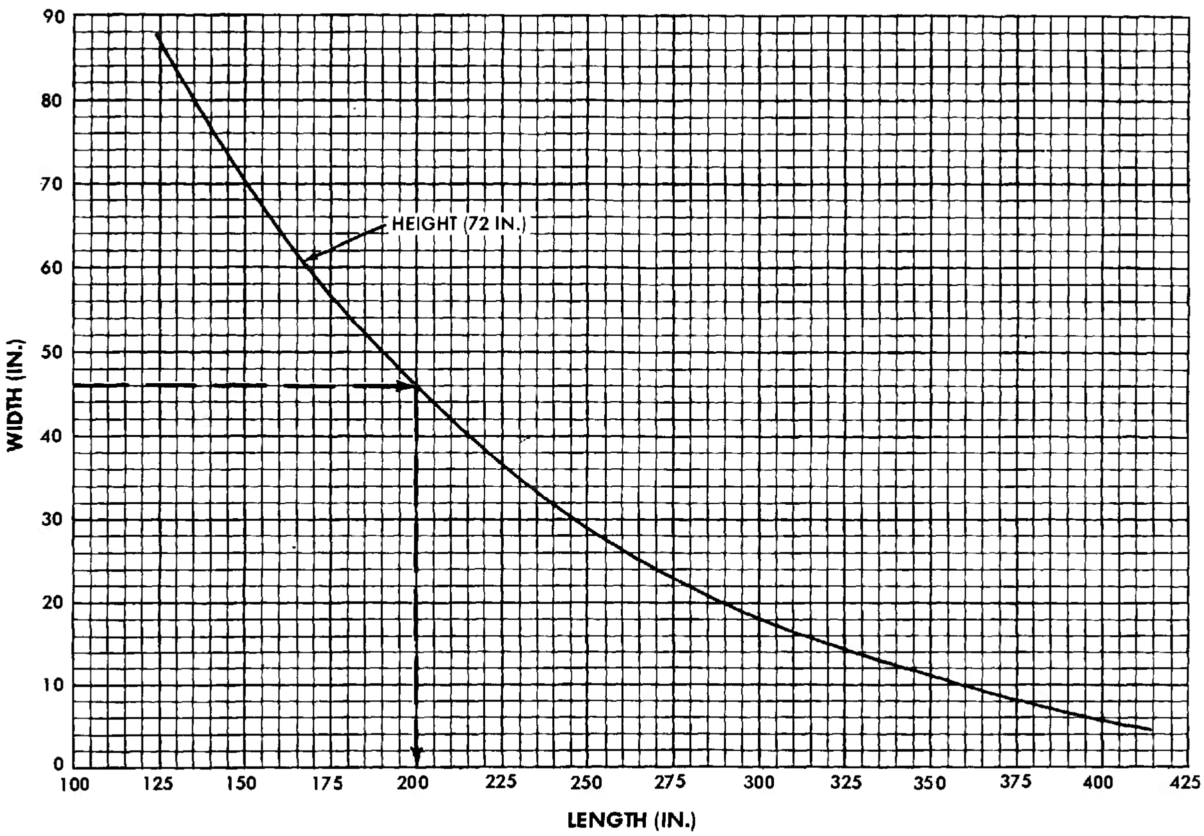


FIGURE 4-65. FORWARD CARGO DOOR PACKAGE SIZE GRAPH, C-130 AIRCRAFT

4—49 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the **C-130** aircraft:

Forward	8.0
Aft	**1.5**
Side	**1.5**
Vertical	**2.0**

A 5 0 CARGO LOADING AND UNLOADING PROVISIONS

Loading and unloading provisions for the C-130/382B include auxiliary loading ramps, snatch blocks, and a portable winch.

4—50.1 AUXILIARY LOADING RAMPS. Auxiliary truck-loading and auxiliary ground-loading ramps are used to bridge any gap between ramp and truck, platform, or ground. Two auxiliary truck-loading ramps, **36** inches long by *26* inches wide, are furnished with each aircraft. The load limit for each auxiliary truck-loading ramp is **12,500** pounds.

Two auxiliary ground-loading ramps, 66 inches long by **21** inches wide, are also furnished with each aircraft. The maximum load that may be imposed on these ramps is 6500 pounds per wheel or 13,000 pounds per axle.

4—50.2 SNATCH BLOCKS. Two movable snatch blocks are provided for winching loads into and within the aircraft. The cable to the prime mover may be routed either through the rear or forward cargo door. Vehicles up to 25,000 pounds can be winched up the ramp using the snatch blocks.

4—50.3 PORTABLE WINCH. A portable cargo winch may be attached to any 10,000-pound or 25,000-pound tiedown fitting. The winch is capable of winching any authorized load into the aircraft with the aid of snatch blocks.

SECTION XI

C-131E

4-51 GENERAL DESCRIPTION

The **C-131E** is a twin-engine, low-wing monoplane with a fully retractable tricycle landing gear (Fig. 4-66). It is used primarily as a cargo transport with a maximum payload of 7100 pounds.

4-52 CARGO COMPARTMENT

The cargo compartment extends from station 176.5 to station 754.5 (Fig. 4-67). The total volume of the cargo compartment is 2305 cubic feet with a floor area of 373 square feet.

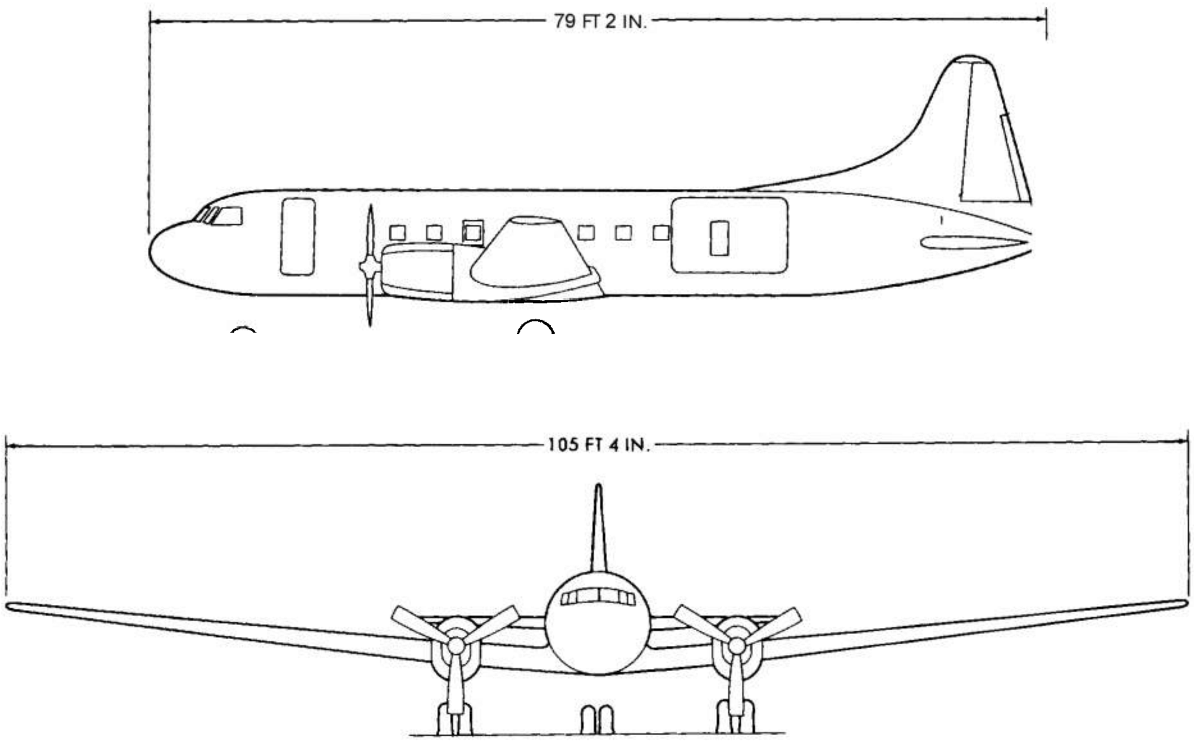


FIGURE 4-66. C-131E AIRCRAFT

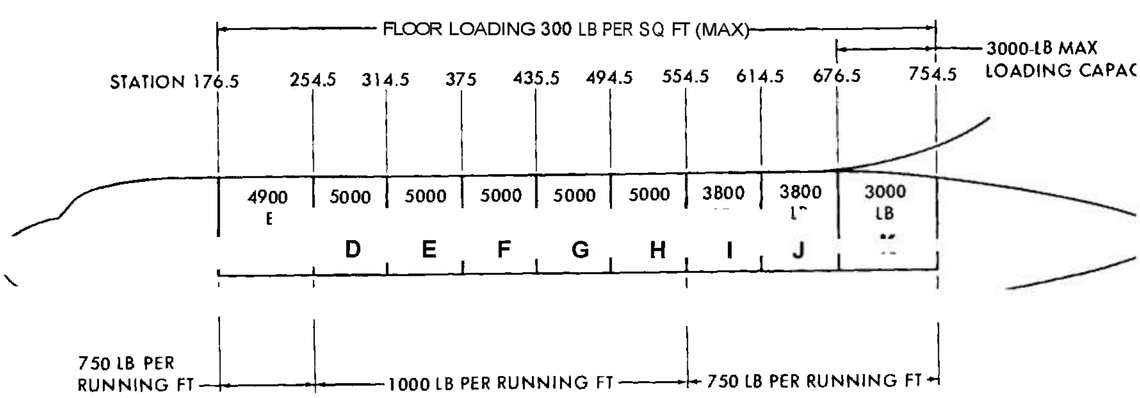


FIGURE 4-67. CARGO COMPARTMENT WEIGHT LIMITS, C-131E AIRCRAFT

4—52.1 FLOOR LOADING. The cargo compartment floor is the sandwich-type, metal honeycomb core, with top and bottom faces of aluminum alloy. All flooring is sectionalized into small panels for easy removal. The maximum floor loading capacities are shown in Fig. **4—67.**

4—52.2 ANCHORING ARRANGEMENT. A total of **168** tiedown fittings are provided on the cargo floor. Eight of these fittings are rated at **10,000** pound and **160** are rated at **5000** pound. The location of the tiedown fittings is shown in Fig. **4—68.**

4—53 CARGO DOORS

4—53.1 MAIN ENTRANCE DOOR. The main entrance door is located on the left side of the fuselage, forward of station **176.5.** The main entrance door is primarily used to gain entrance to the aircraft but may be used to load small items of cargo. The door entrance is **76.8** inches high and **36** inches wide.

4—53.2 CARGO DOOR. The cargo door is located on the left side of the fuselage between stations **554.5** and **676.5.** The door dimensions are shown in Fig. **4—69.** Maximum package size that can be loaded through the cargo door can be determined from Table **4—8.**

4—54 RESTRAINT CRITERIA

Not available.

A 5 5 CARGO LOADING AND UNLOADING PROVISIONS

No special loading and unloading provisions are provided for the **C-131E** aircraft.

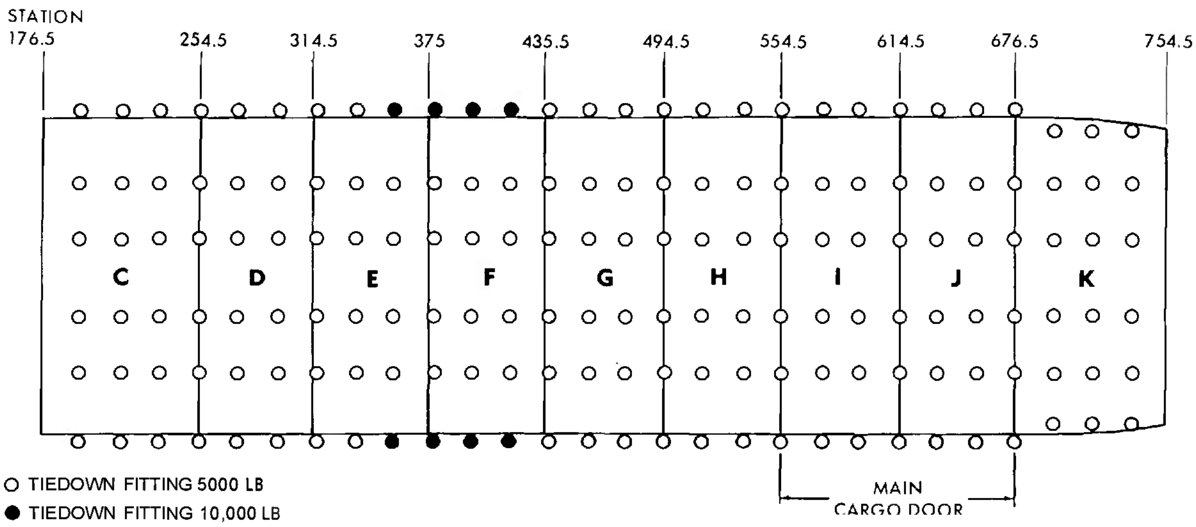


FIGURE 4-68. ANCHORING ARRANGEMENT, C-131E AIRCRAFT

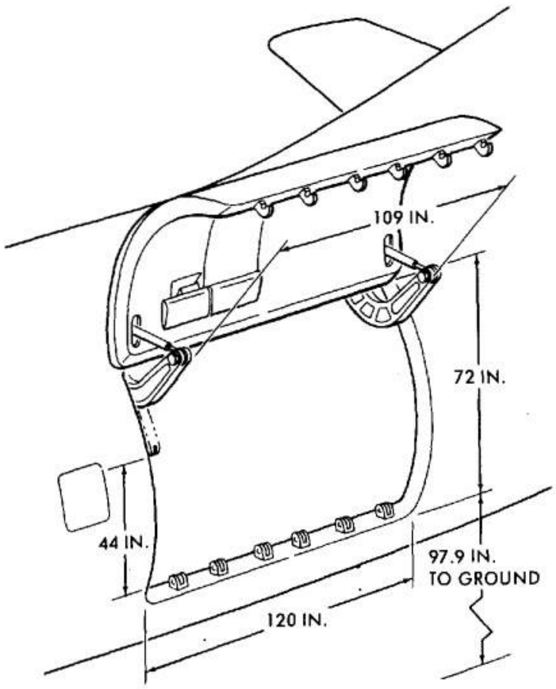


FIGURE 4–69. CARGO DOOR DIMENSIONS, C-131E AIRCRAFT

TABLE 4–8. MAXIMUM CARGO DOOR PACKAGE SIZE, C-131E AIRCRAFT

WIDTH (IN.)	44 AND UNDER	45	50	55	60	65	70	72
	MAXIMUM LENGTH (IN.)							
5	499'	499'	392	316	267	228	203	203
10	499*	468	335	277	239	207	184	184
15	490	387	293	247	217	189	167	167
20	409	331	260	223	197	174	155	155
25	350	289	234	203	182	162	144	144
30	306	255	212	186	168	151	133	133
35	272	230	195	172	157	141	125	125
40	245	208	179	160	148	133	117	117
45	222	190	167	150	138	126		
50	203	175	156	141	131	119		
55	188	162	146	133	124			
60	173	151	137	126	118			
65	162	141	130	119				
70	152	133	123	116				
75	142	124	117					
80	134	118	114					
85	126	111						
90	119	108						
92	117							

* Limited by maximum cargo compartment length forward of aft edge of cargo door.

SECTION XII

C-133

A 5 6 GENERAL DESCRIPTION

The C-133 is a high-wing, four-engine (turboprop), long-range, heavy-duty, pressurized, cargo carrier (F'ig. 4–70). It is designed to transport general cargo of low, medium, and high density, and military vehicles and missiles; however, if required, 120high-density seats, or 55 litters, may be installed. It can carry approximately 42,000 pounds of cargo on design-range missions and approximately 100,000 pounds of cargo on shorter missions at design gross weight. There are two models (A and B) of the C- 133 aircraft, the primary difference being the configuration of the aft cargo loading door.

A 5 7 CARGO COMPARTMENT

The cargo compartment extends from station 238 to station 1406 and is 1168 inches long, 144 inches wide (width is limited to 142 inches at the floor to 2 inches above the floor), and has a minimum height of 143 inches (except at stations 238 and 278, where the height is 134 inches). The cargo compartment volume is approximately 13,000 cubic feet and is effectively utilized when loaded with approximately 4900 cubic feet of palletized cargo. The dimensions and critical contours of the cargo compartment are shown in Fig. 4–7 1.

4—57.1 FLOOR LOADING. The cargo floor, including the rear cargo ramp, has an area of approximately 1141 square feet. Two high-strength treadways, 41 inches wide and 39 inches apart, extend from station 238 to station 1406. Contact-area pressures and compartment load limitations for general (distributed) and concentrated cargo (including vehicles) are presented in Table 4–9. For concentrated cargo and vehicles,

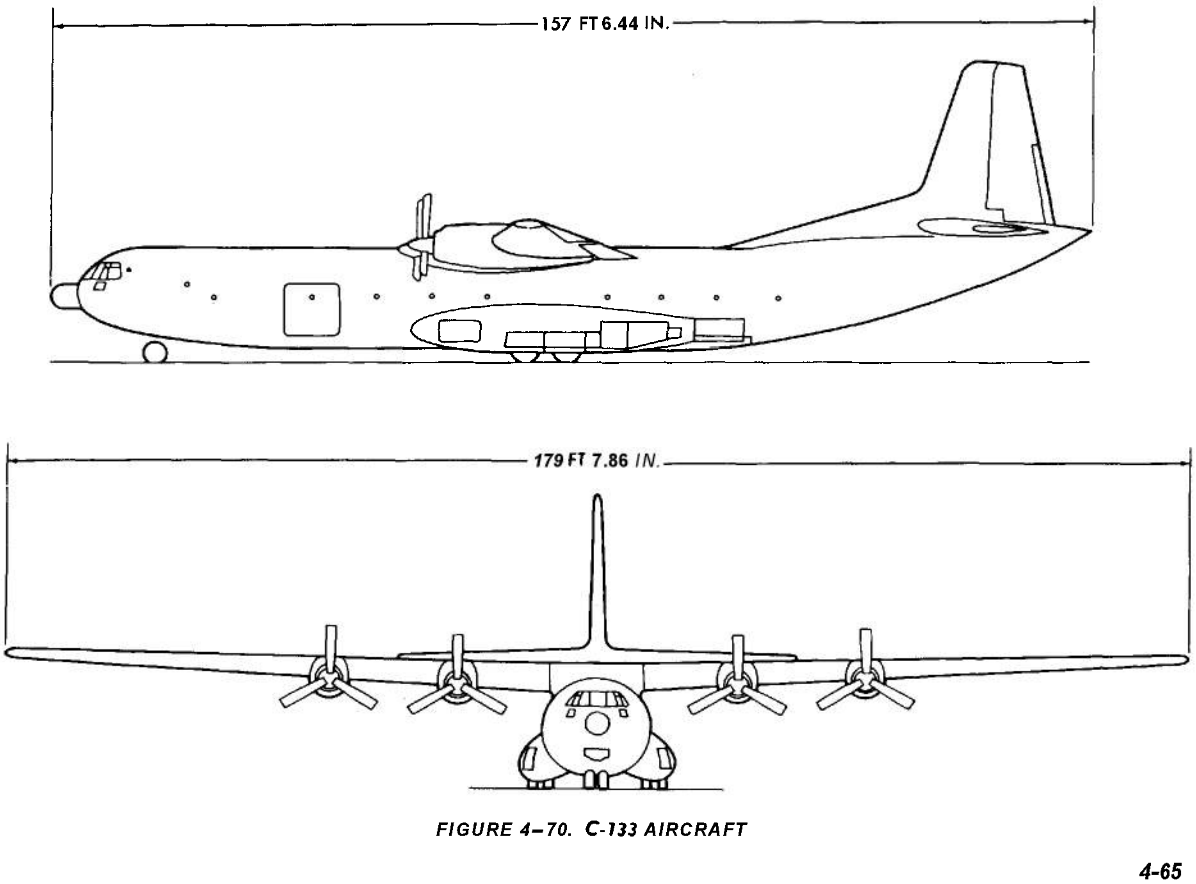
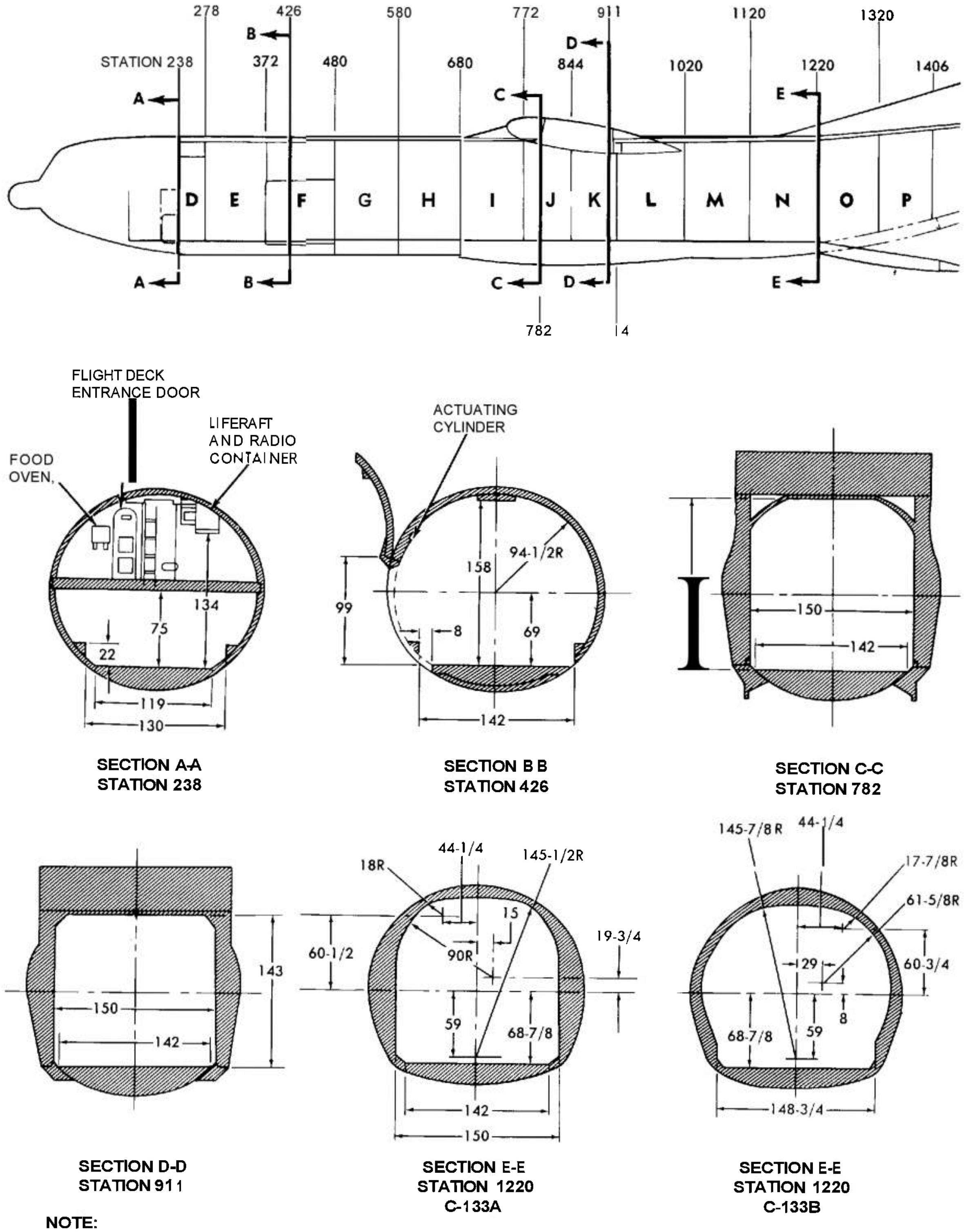


FIGURE 4–70. C-133 AIRCRAFT



NOTE:
DIMENSIONS IN INCHES

FIGURE 4–71. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-133 AIRCRAFT

TABLE 4-9. CARGO COMPARTMENT LOADING DATA, C-133 AIRCRAFT

ZONE	COMPARTMENT	REFERENCE DATA: FLOOR AREA (ft^2)	REFERENCE DATA: VOLUME (ft^3)	CONTACT-AREA PRESSURES: GENERAL CARGO (psi)	CONCENTRATED CARGO (psi): OFF TREADWAYS	CONCENTRATED CARGO (psi): TREADWAYS	PNEUMATIC TIRED VEHICLE (psi)	COMPARTMENT LOAD LIMITATIONS (STOWED): GENERAL CARGO (lb)	CONCENTRATED CARGO (lb): OFF TREADWAYS	CONCENTRATED CARGO (lb): TREADWAYS	CONCENTRATED CARGO (lb): COMPT MAXIMUM	VEHICLES (POUNDS): SINGLE AXIS	VEHICLES (POUNDS): TANDEM AXIS	ZONE LOAD LIMITATIONS: ZONE BREAKDOWN	ZONE LOAD LIMITATIONS: MAXIMUM WEIGHT (lb)
1	D	32	370	2.08	30	50	90	4,000	4000	4,000	4,000	5,000		278 TO 238	5,000
	E	92	1103	2.08	30	50	90	9,400	4000	6,000	12,000	12,000		372 TO 238	12.000
	F	107	1270	2.08	30	50	90	12,960	4000	6,000	12,000	13,000	17.200	471 TO 238	18,000
	G	99	1175	2.08	30	50	90	12,000	4000	7,000	14,000	14,000	26.000	545 TO 238 580 TO 238	28,000 33.250
	H	99	1175	2.08	30	50	90	20.000	4000	8,000	16,000	16,000	26.000	680 TO 238	41,000
	I	91	1080	2.08	30	50	90	25,300	4000	10,000	20,000	20,000	44,000	772 TO 238	57,000
2	J	71	745	2.60	30	50	90	27,150	4000	10,000	20,000	20,000	44,000	772 TO 914	76,000
	K	69	722	2.60	30	50	90	26,100	4000	10,000	20,000	20,000	44,000	772 TO 914	TOTAL
3	L	105	1245	2.08	30	50	90	29,150	4000	8,000	16,000	16,000	30,000	914 TO 1406	48,000
	M	99	1175	2.08	30	50	90	20,000	4000	7,000	14,000	14,000	26,000	1020 TO 1406	33,250
	N	99	1175	2.08	30	50	90	12,000	4000	7,000	14,000	14,000	17,200	1120 TO 1406	18,000
	O	95	1078	2.08	30	50	90	* 6,000	4000	3,000	6.000	6,000		1120 TO 1406	7,200
	P	83	710	2.08	30	50	90	1,200	600	600	1,200	1,200			

* When no load is stowed in compartment P, 10,000 pounds of general cargo may be carried in compartment O. With no load in compartment P, an 8000-pound axle load or concentrated load (4000 pounds each treadway) may be stowed in compartment O.

both compartment load and zone load limitations must be checked. Zone load limitations are also presented in Table 4—9.

4—57.2 ANCHORING ARRANGEMENT. Tiedown fittings of 5000-, 10,000-, 25,000-, and 35,000-pound capacities are installed on the cargo floor and ramp area. Locations of these fittings are shown in Fig. 4—72. The 5008-pound capacity fittings are located at the juncture of the cargo floor and the cargo compartment wall, and along the edge of the ramp area. On C-133A aircraft, 5000-pound capacity fittings are located on a 20-inch grid pattern aft of station 1350. The 10,000-pound capacity fittings are located on a 20-inch grid pattern over the entire cargo floor and ramp area, except as shown for the C-133A aircraft. The 25,000-pound capacity fittings are located symmetrically about the cargo floor centerline at intervals of 80 to 100 inches. The 35,000-pound capacity fittings are located at the juncture of the cargo floor and main frames between stations 278 and 1350.

4—58 CARGO DOORS AND RAMPS

There are two main cargo door configurations utilized with the C-133 aircraft. The cargo door configuration for the C-133A aircraft is shown in Fig. 4—73. This configuration consists of two doors — the rear cargo door and the rear cargo ramp. The rear cargo door is hinged at the aft end and opens upward, affording an opening 150 inches from the ground and 100 inches from the rear cargo ramp (with ramp in horizontal position). The maximum size cargo package that may be loaded through the aft cargo door of the C-133A aircraft may be determined graphically as shown in Fig. 4—74. For example, a package having a height of 107 inches and a width of 120 inches cannot exceed 750 inches in length.

The cargo door configuration for the C-133B aircraft is shown in Fig. 4—75. This door configuration consists of three doors — the rear cargo door (or ramp), rear cargo center (clamshell) door, and the rear cargo aft door. The rear cargo center (clamshell) door opens downward and outboard. The rear cargo aft door opens upward, affording an opening 159 inches from the ground and 109 inches from the cargo ramp (with ramp in horizontal position). The maximum size cargo package that may be loaded through the C-133B aircraft door opening may be determined graphically as shown in Fig. 4—76. For example, a package having a height of 123 inches and a width of 140 inches cannot exceed 700 inches in length.

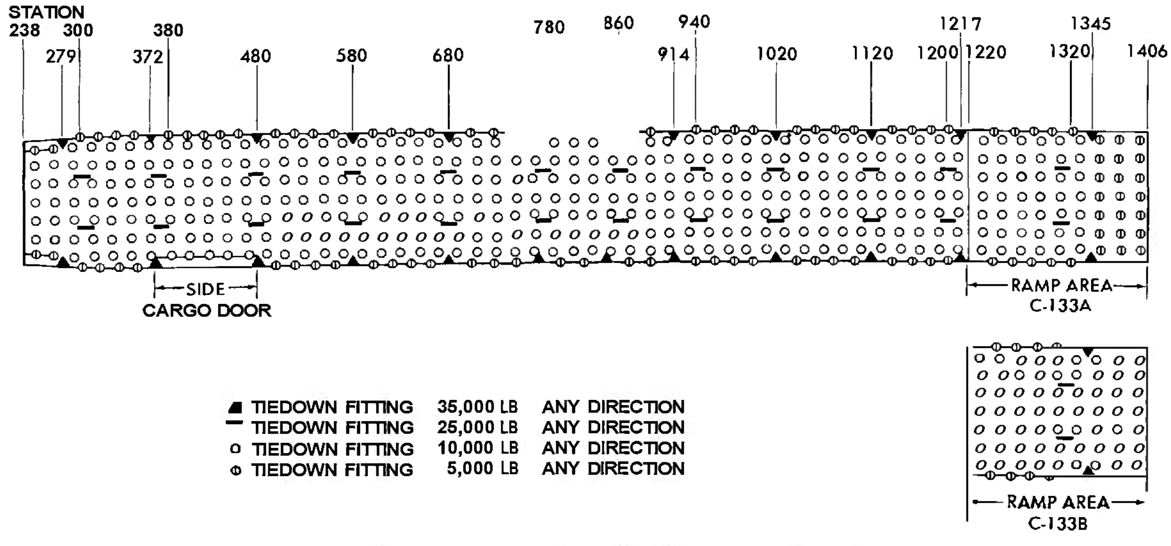
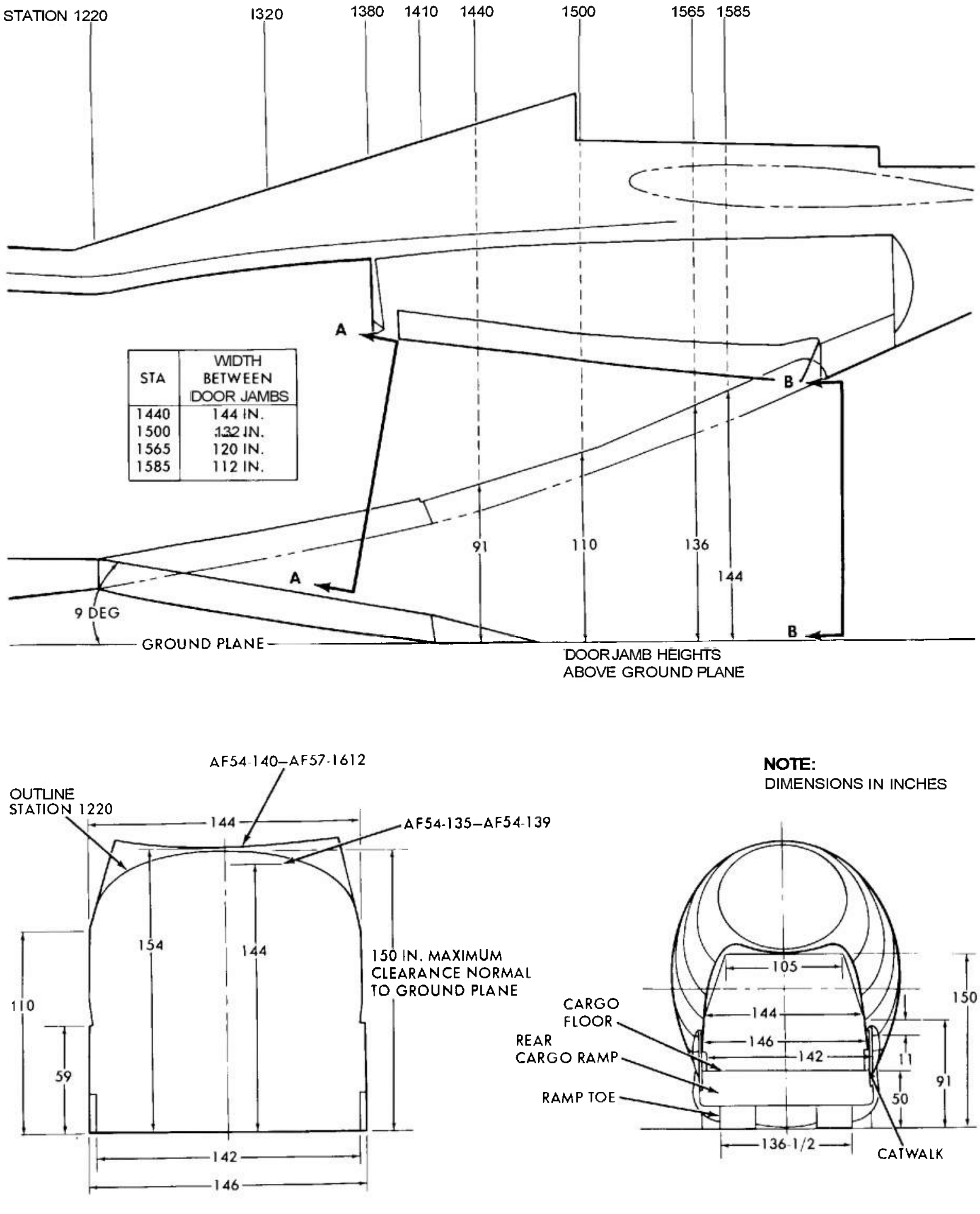


FIGURE 4—72. ANCHORING ARRANGEMENT, C-133 AIRCRAFT



STA	WIDTH BETWEEN DOOR JAMBS
1440	144 IN.
1500	132 IN.
1565	120 IN.
1585	112 IN.

SECTION A-A
NORMAL TO REAR CARGO RAMP

SECTION B-B
NORMAL TO GROUND PLANE

FIGURE 4–73. MAIN CARGO DOOR, C-133A AIRCRAFT

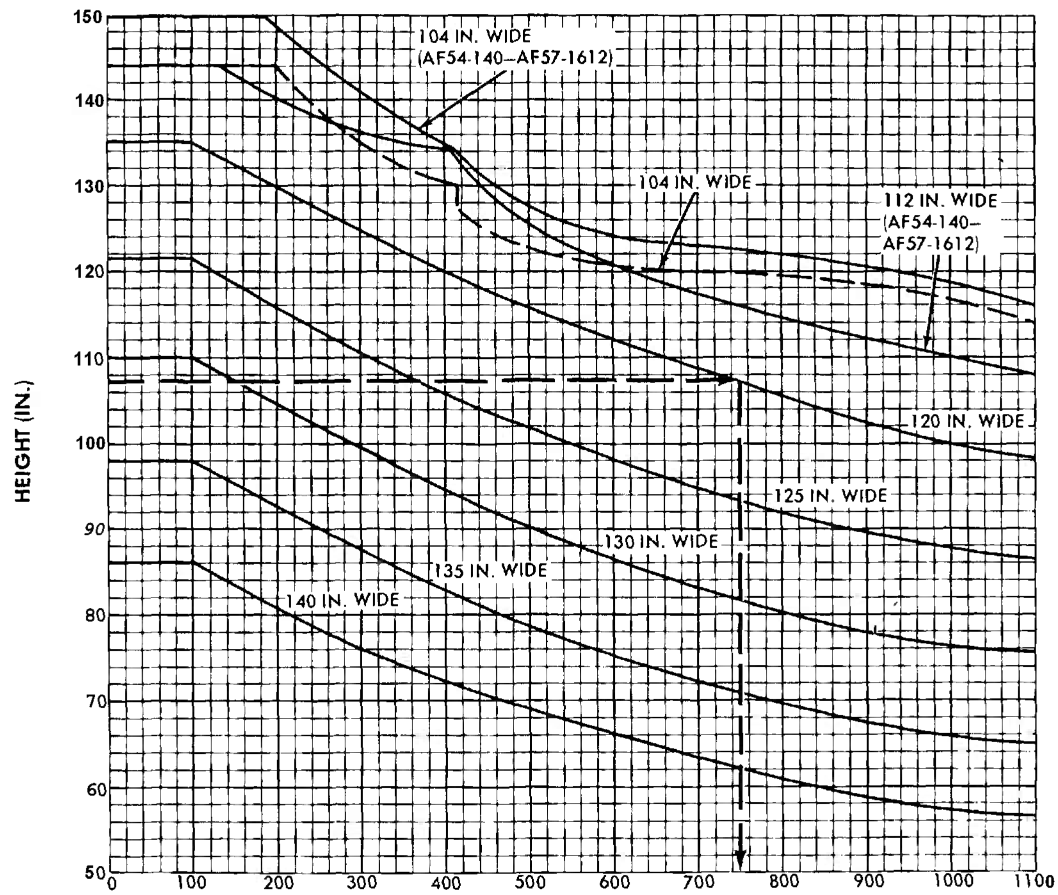


FIGURE 4-74. MAIN CARGO DOOR PACKAGE SIZE GRAPH, C-133A AIRCRAFT

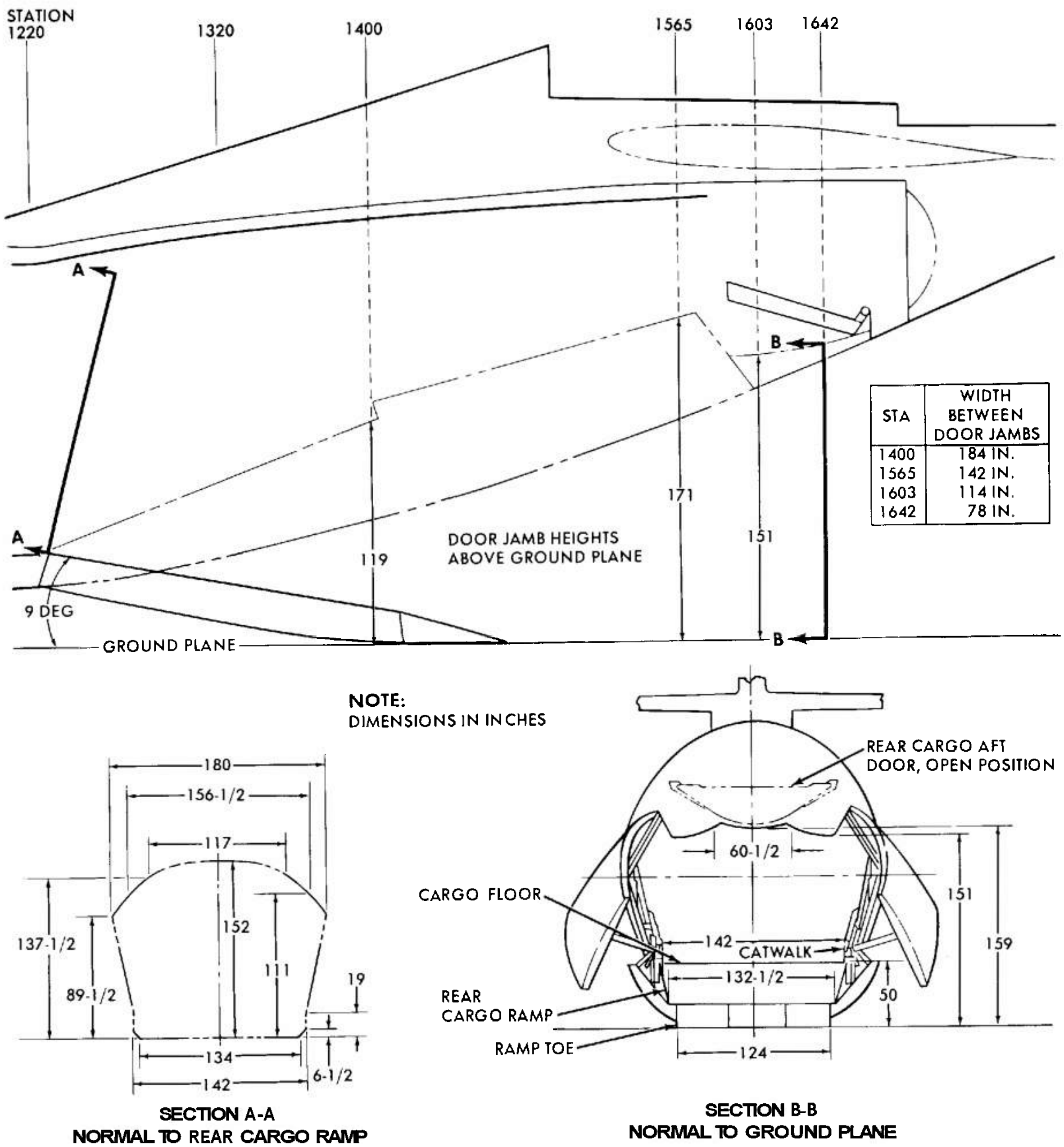
4—58.1 CARGO RAMPS. The cargo ramps used with both door configurations are similar and have dimensions of approximately 186 inches in length, 136 inches in width, and an area of approximately 178 square feet. In any intermediate position, the ramp is capable of supporting a 25,000-pound uniformly distributed load.

4—58.2 SIDE CARGO DOOR. The side cargo door extends from station **372** to station **480** and is located approximately 50 inches above ground on the left-hand side of the aircraft. The door dimensions are approximately 106 inches wide and 100 inches high. The maximum package size that can be loaded through the opening may be determined graphically as shown in Fig. 4—77. For example, a package having a width of 50 inches and a height of 96 inches will be limited to a length of **240** inches.

4—59 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-**133** aircraft:

Forward	3.0
Aft	1.5
Side	**1.5**
Vertical	2.0



STA	WIDTH BETWEEN DOOR JAMBS
1400	184 IN.
1565	142 IN.
1603	114 IN.
1642	78 IN.

FIGURE 4-75. MAIN CARGO DOOR, C-133B AIRCRAFT

4-60 CARGO LOADING AND UNLOADING PROVISIONS

Two removable ramp toe sections, each 30 inches wide, are furnished to provide an extension from the ground onto the cargo **ramp.** The toes can be adjusted laterally to accommodate tread widths up to 136-1/2 inches on **C-133A** aircraft and 124 inches on **C-133B** aircraft. **A** portable winch, which' can be attached to the 25,000- or 35,000-pound tiedown fittings, is furnished. The winch is capable **of** a 15,000-pound draw-bar pull. Heavy cargo may be winched into the aircraft using an externally located prime mover and two cargo loading sheaves. The sheaves may be used with a winching cable **of** 3/4-inch diameter or less. The maximum allowable cable load is 20,000 pounds.

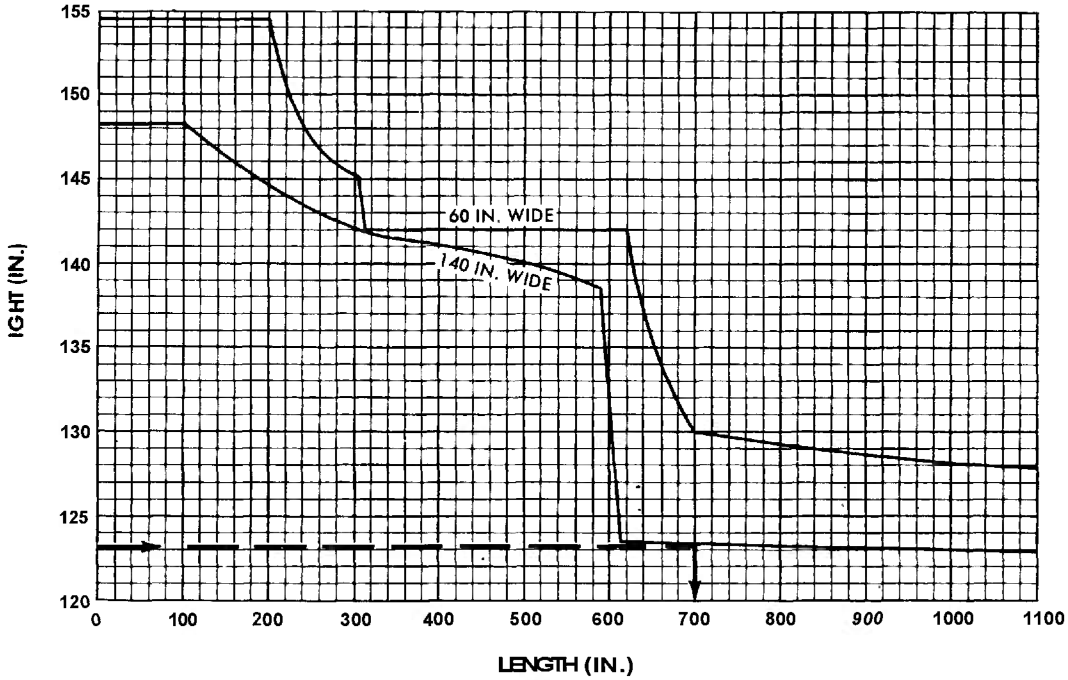


FIGURE 4-76. MAIN CARGO DOOR PACKAGE SIZE GRAPH, C-133B AIRCRAFT

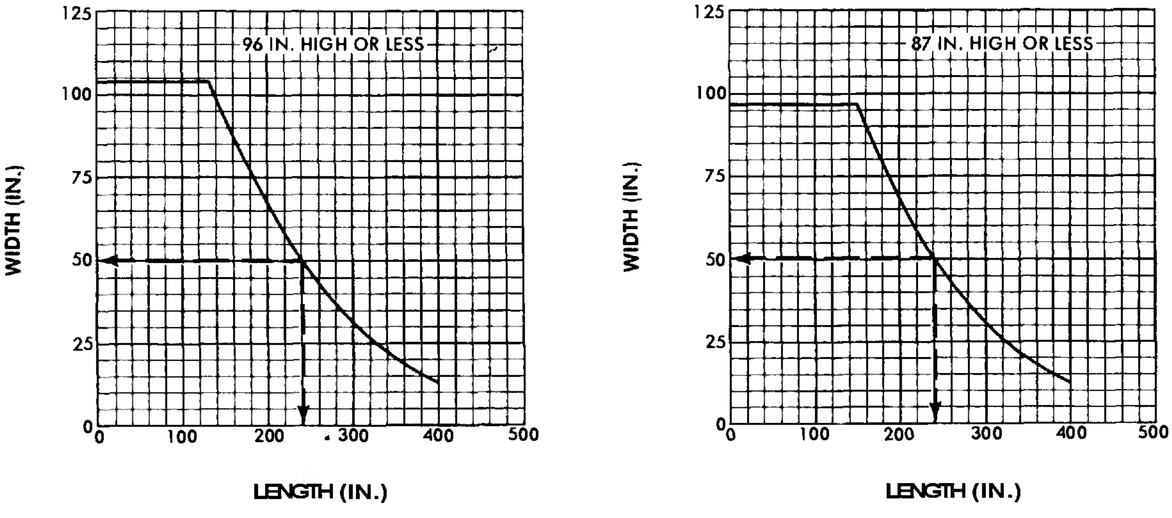


FIGURE 4-77. SIDE CARGO DOOR PACKAGE SIZE GRAPH, C-133 AIRCRAFT

SECTION XIII

C-135

4—61 GENERAL DESCRIPTION

The C-135 is a long-range, low swept-back wing transport (Fig. 4—78). There are two models of this aircraft used to transport troops, palletized cargo, or combinations of these loads —the C-135A and C-135B. The most distinguishing feature of the C-135 is its single swept tail. The cargo compartment is equipped with roller conveyors which will accommodate the 463L pallet system. This aircraft is designed for side loading only.

4-62 CARGO COMPARTMENT

The cargo compartment extends aft from the electronics cabinet to station 1240. The cargo compartment is 860 inches long, 129 inches wide at floor level, and 85 inches high. Dimensions and contours of the cargo compartment are shown in Fig. 4—79. The cargo compartment volume is approximately 5478 cubic feet. The cargo pallet system may be installed in either the narrow (88-inch) or wide (108-inch) configuration. In the narrow configuration, the cargo compartment will hold seven HCU-6E pallets, Military Specification MIL-P-27443, loaded to a maximum of 8000 pounds each. In the wide configuration, the cargo compartment will hold nine pallets loaded to a maximum of 8000 pounds each. Maximum dimensions for loading cargo pallets are shown in Fig. 4—80.

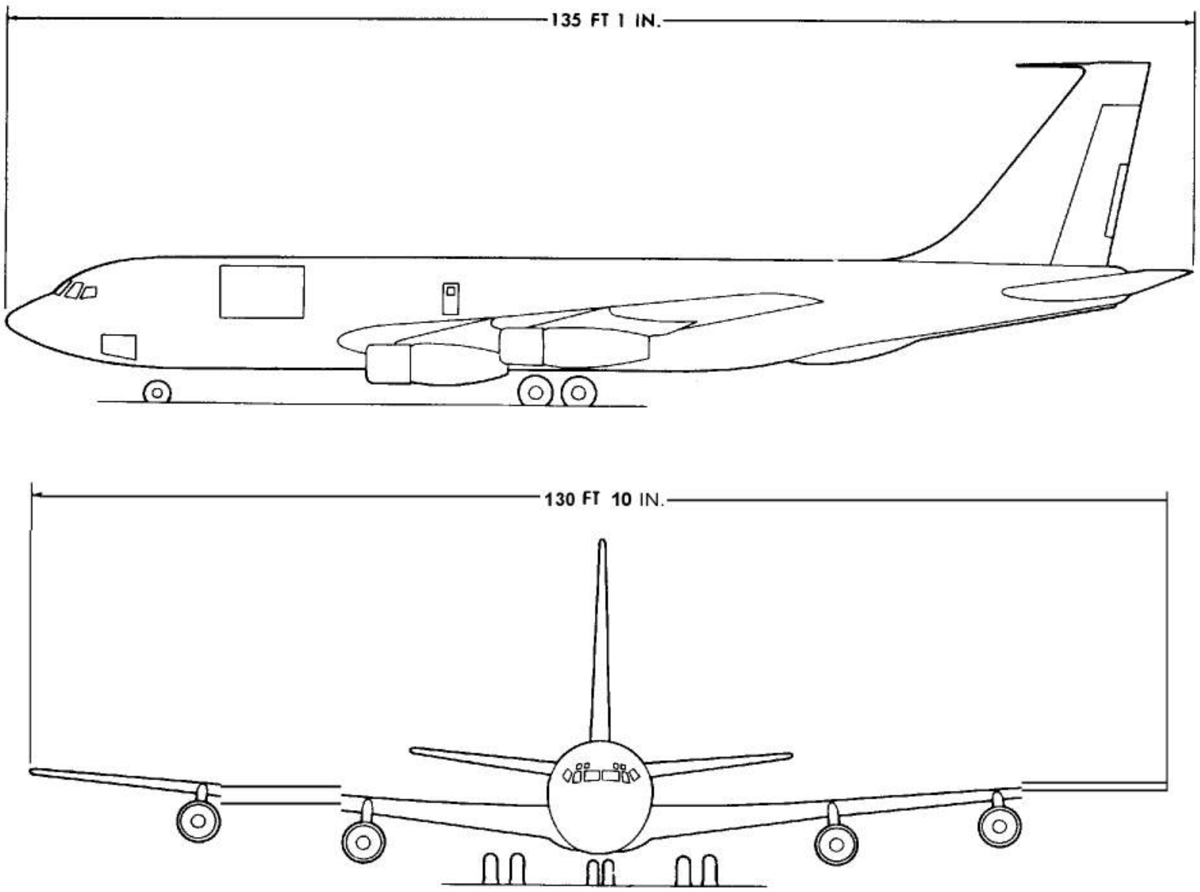
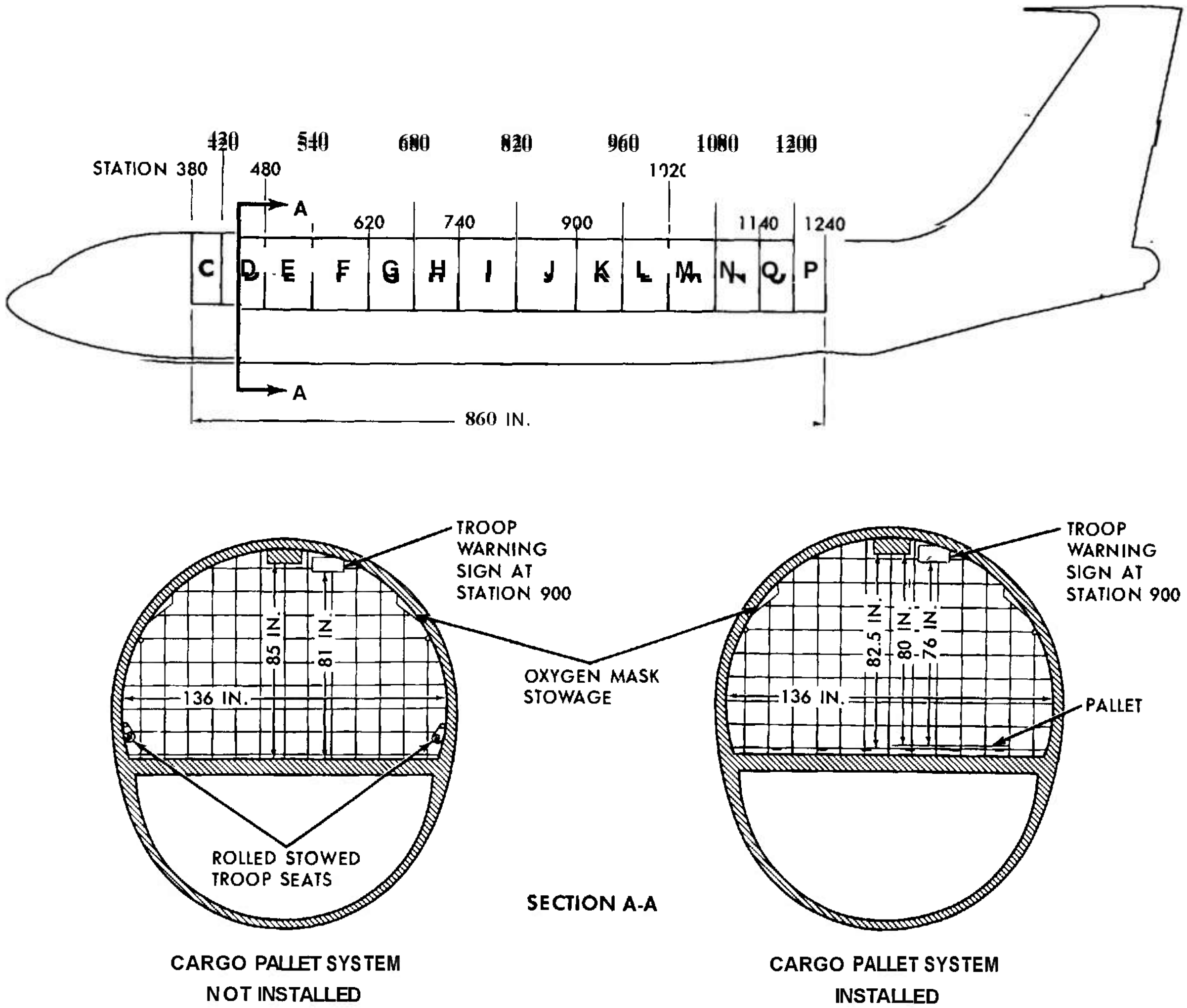


FIGURE 4—78. C-135 AIRCRAFT



NOTE:
DO NOT PLACE CARGO IN
FRONT OF AIR CONDITION DUCT

FIGURE 4-79. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-135 AIRCRAFT

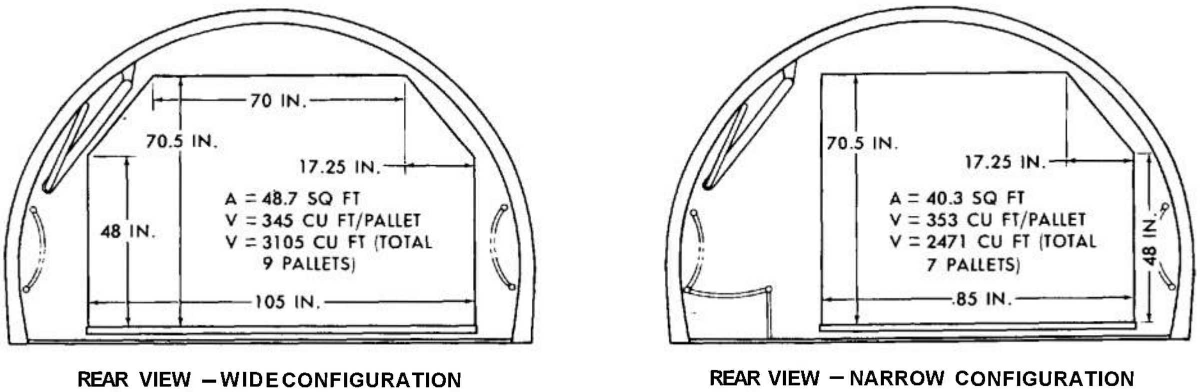


FIGURE 4-80. PALLET VOLUME DIAGRAM, C-135 AIRCRAFT

4—62.1 FLOORLOADING. The cargo compartment floor consists of reinforced aluminum panels with removable skid strips and integral seat tracks. The floor will support evenly distributed loads of 200 pounds per square foot.

4—62.2 ANCHORING ARRANGEMENT. Cargo floor tiedown fittings for the cargo compartment are shown in Fig. 4—81. Two different types of tiedown fittings are installed, most of which are removable. From station 390 to station 1240, there are eighty-three 10,000-pound tiedown fittings and one hundred sixty-eight 5000-pound tiedown fittings. The 5000- and 10,000-pound capacity floor fittings are arranged in a regular 20-inch pattern in the cargo floor.

4-63 CARGODOOR

Access to the cargo compartment for loading and unloading of cargo and personnel is provided by the cargo door at the forward, left side of the fuselage, between stations 420 and 540. The door opening is approximately 78 inches high by 117 inches wide (Fig. 4—82). Door actuator supports at the top create two 8- by 13-inch obstructions. The lower sill height above ground varies according to the aircraft load. The maximum height is approximately 132-1/2 inches, the minimum height is approximately 108-3/4 inches. The door is hinged along its top edge and opens upward approximately 140 degrees from the closed position. Approximate maximum package sizes of rectangular packages of various lengths and widths that can be loaded through the cargo door are indicated in Fig. 4—83. For example, a package having a height of 50 inches and a width of 90 inches, the maximum length is restricted to 160 inches.

4-64 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C-135 aircraft:

Forward	8.0
Aft	1.5
Side	1.5
Vertical	2.0

A 5 CARGO LOADING AND UNLOADING PROVISIONS

The aircraft is equipped with the cargo pallet system (roller conveyors) for loading and unloading cargo. The pallet system includes a pallet guide rail assembly and door frame protectors. A loading support strut must be installed at the fuselage *aft* jack point when pallets are to be loaded.

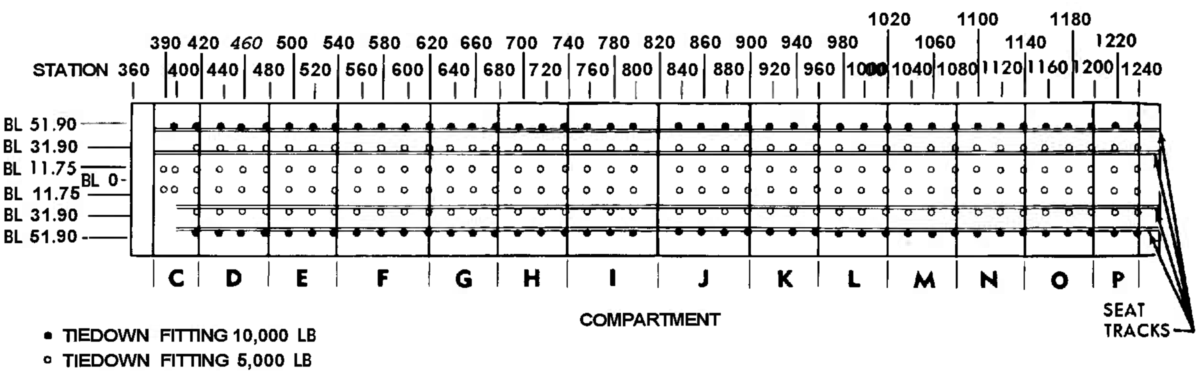
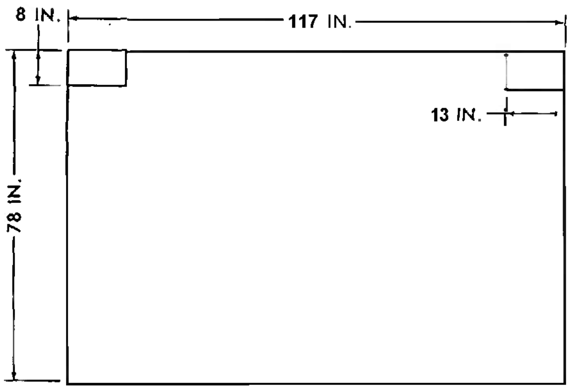
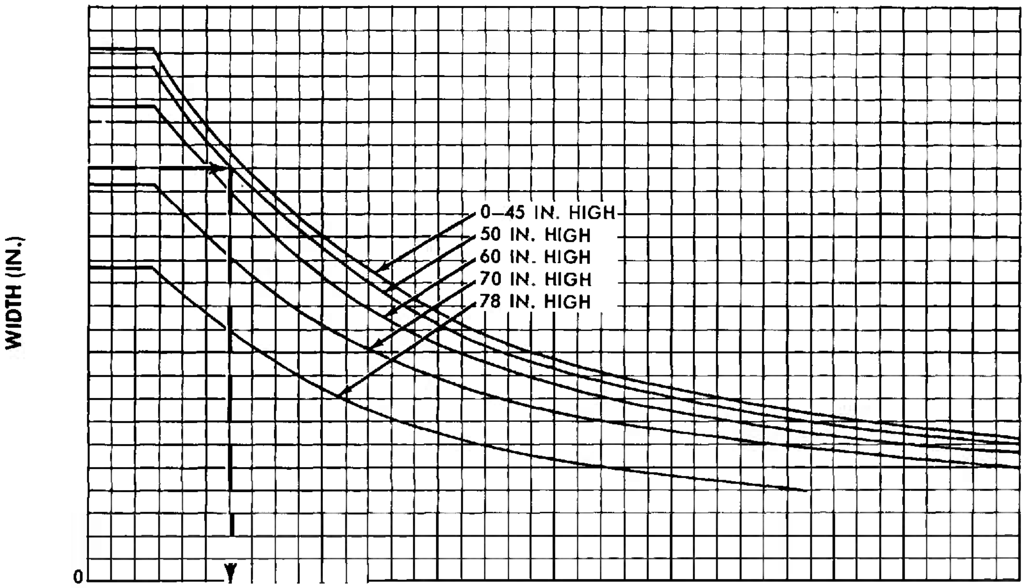


FIGURE 4–81. ANCHORING ARRANGEMENT, C-135 AIRCRAFT



NOTE:
HEIGHT IS DECREASED BY 2.5 IN. WHEN
PALLET SYSTEM IS INSTALLED.

FIGURE 4-82. CARGO DOOR, C-135 AIRCRAFT



SECTION XIV

C-141

4—66 GENERAL DESCRIPTION

The G141 is a long-range, high swept-back wing transport **(Fig. 4—84).** It is powered by four turbofan engines. The **C-141** is designed to transport troops, vehicles and palletized cargo, or any combination of these loads. It is also used for air delivery. The most distinguishing feature **of** the **C-141** is its high T-tail. The **C-141** is equipped with the integral dual-rail system. Four rows of roller conveyors run the entire length of the cargo compartment and ramp. Restraint rails are installed to be compatible with the **463L** pallet system. The rollers and restraining rail **for** the pallets or airdrop platforms can be quickly retracted into recesses to provide **a flat**, smooth floor which is suitable for bulk loading, rolling stock, troops, and litter patients.

A 7 CARGO COMPARTMENT

The clear cube of the cargo compartment, from station **452** to **1292,** is **840** inches long by **123** inches wide by **109** inches high, with a total volume of **6524** cubic feet. Dimensions and contours of the cargo compartment are shown in Fig. **4—85.** The height and width of the cargo compartment are reduced **2** inches across the upper outside corners at stations **1198** and **1238** by the troop door track. Whenopened, the troop doors reduce the clearance height at the upper left and right corners by **20** inches. When the roller conveyor is turned upright, the usable height will be reduced **1.5** inches. Additional cargo can be placed on the ramp, which is **133.25** inches long and **123** inches wide, with a total volume of **816** cubic feet.

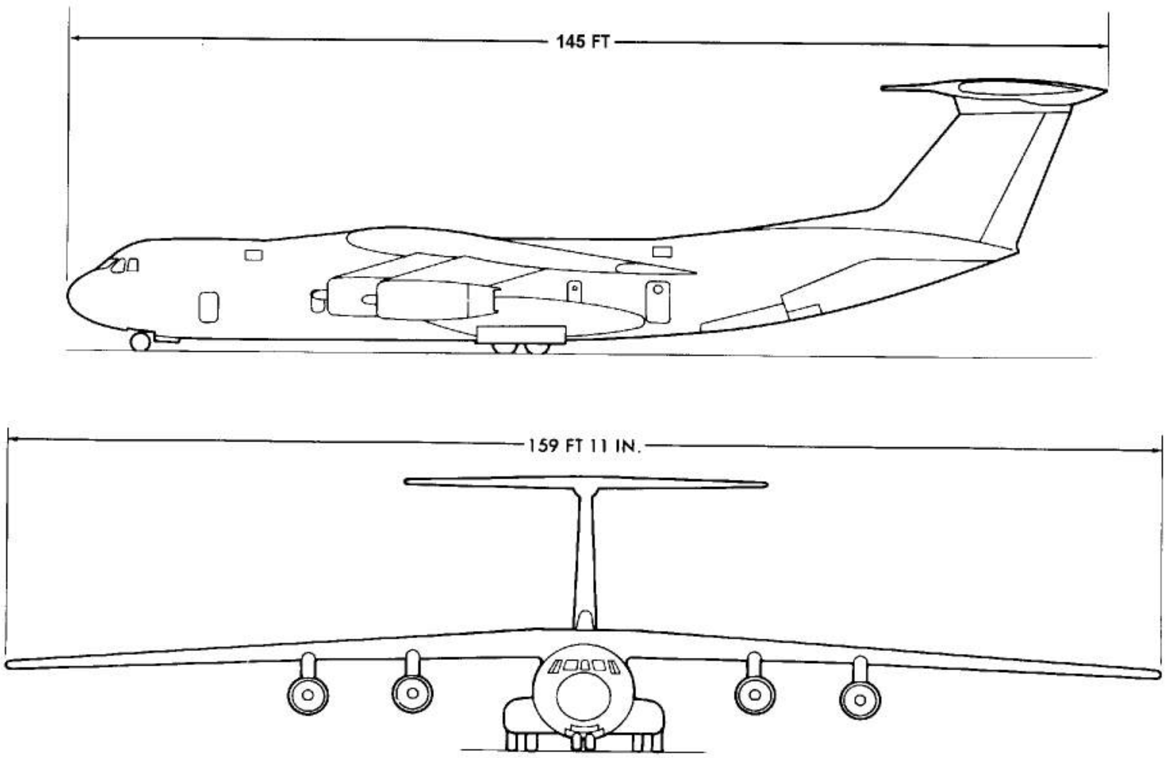
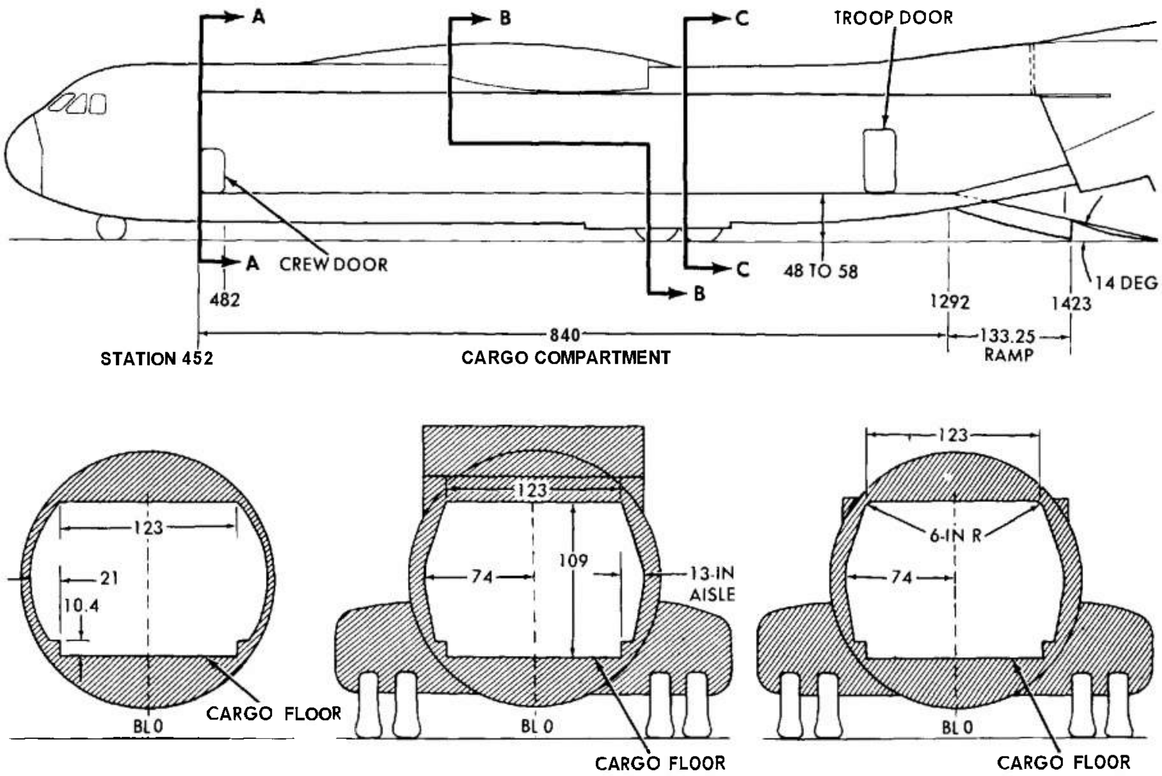


FIGURE 4–84. C-141 AIRCRAFT

NOTES:
1. DIMENSIONS IN INCHES.
2. THE HEIGHT AND WIDTH OF THE COMPARTMENT ARE REDUCED 2 IN. ACROSS THE UPPER OUTSIDE CORNERS OF THE COMPARTMENT AT FUS STA 1198 AND 1238 BY THE TROOP DOOR TRACKS.
3. WHEN THE ROLLER CONVEYORS ARE TURNED UPRIGHT, USABLE HEIGHT WILL BE REDUCED 1.5 IN.



TYPICAL FROM STA 452 TO 1108 EXCEPT AS NOTED

SECTION A-A

TYPICAL AT STA 734.7 AND 958

SECTION B-B

TYPICAL AT STA 998 AND 1058

SECTION C-C

FIGURE 4-85. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, C-141 AIRCRAFT

Up to ten 108- by 88-inch HCU-6/E cargo pallets can be carried in the aircraft on the integral dual-rail system. Nine pallets, each capable of carrying up to 10,000 pounds, can be carried in the main cargo compartment. The tenth pallet is placed on the ramp. Normal stacking of cargo to a height of 96 inches above the surface of the pallet will provide a vertical clearance between the top of the load and the cargo overhead of approximately 9 inches. The maximum stacking height for cargo on the ramp pallet is 76 inches above the surface of the pallet. The maximum allowable load on the ramp is 7500 pounds.

The maximum load that may be extracted from the C-141 during airdrop operations is 35,000 pounds. Cargo installed on type II modular platforms, 108 inches wide, is extracted with extraction parachutes through the rear doors.

4-67.1 FLOOR LOADING. The cargo floor is designed for a uniformly distributed load of 300 pounds per square foot and ***2000*** pounds per linear foot, except in the high strength area between stations 678 and 998 where the floor limit is 400 pounds per square foot and 3000 pounds per linear foot. The ramp may be loaded to ***200***

pounds per square foot, or 1000 pounds per linear foot, with a total load limitation of 7500 pounds. The two 34-inch wide treadways have a maximum axle load of 10,000 pounds per axle, except in the high strength area between stations 678 and 998 where the limit is 20,000 pounds per axle. Treadways on the ramp have a maximum axle load of 20,000 pounds when 4 inches of wood shoring are used. Figure 4–86 illustrates total load limits for individual compartments.

4–67.2 ANCHORING ARRANGEMENT. Receptacles for the installation of tiedown fittings are evenly spaced in rows which run the length and width of the cargo compartment and ramp. Three types of receptacles are used: One for connecting individual 10,000-pound fittings; one for connecting individual 25,000-pound fittings; and a continuous-track type for connecting troop seat fittings and/or 10,000-pound fittings. The restraint rail restraint fittings utilize the same receptacles as the 25,000-pound fittings. Tiedown locations and ratings are shown in Fig. 4–87.

4–68 CARGO DOORS AND RAMPS

The aft end of the cargo compartment contains four doors which completely seal the compartment during pressurized flight, but which can be opened for airdrop or when on the ground to permit straight-in loading. All of the doors may be operated hydraulically, in sequence, from controls in the flight station and in the cargo compartment. The integral cargo ramp is hinged to the aft end of the cargo compartment floor. When in a fully closed position, the ramp forms an inclined pressure floor at the end of the cargo compartment. When fully lowered, the ramp forms an angle of approximately 14 degrees with the ground. With the cargo doors opened to the 80-degree position and with the ramp horizontal, a clear opening 123 inches wide and 109 inches high is provided for cargo loading. The cargo floor and ramp crest

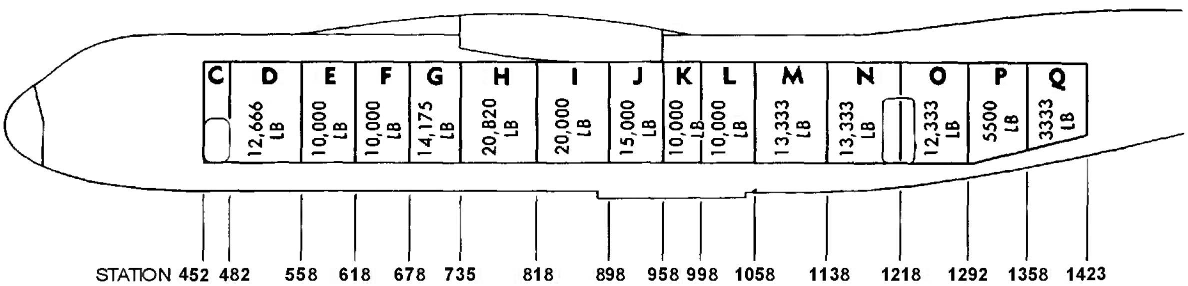


FIGURE 4–86. CARGO COMPARTMENT WEIGHT LIMITS, C-141 AIRCRAFT

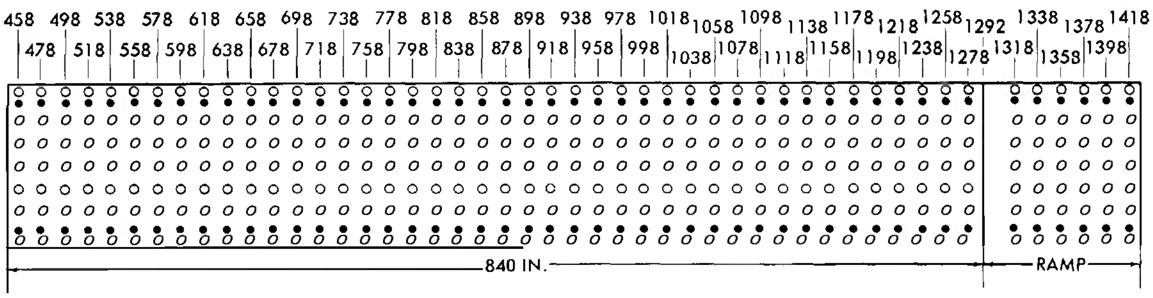


FIGURE 4–87. ANCHORING ARRANGEMENT, C-141 AIRCRAFT

height from the ground will vary between 48 and 58 inches, depending upon cargo and fuel load and strut and tire inflation.

4-69 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the C141 aircraft:

Forward	8.0
Aft	1.5
Side	1.5
Vertical	2.0

4-70 CARGO LOADING AND UNLOADING PROVISIONS

Two auxiliary ground loading ramps, each 8-1/2 feet long and 22 inches wide, are used to bridge the gap between the end of the ramp and a truck bed, or between the end of the ramp and the ground during loading and unloading of vehicles or palletized cargo. The two ramps will support a 20,000-pound, single-axle, rolling load, or that part of a 35,000-pound platform load which rests on the ramp as it passes over them. When loading palletized cargo across the ramps, the pallets must be placed on rollers or shoring with a minimum height of 3-1/8 inches.

An internal winch may be attached to any two 10,000-pound tiedown fittings for winching cargo up the ramp. In addition, external winching is possible by using the two snatch blocks supplied with the aircraft. Each snatch block is rated at a maximum capacity of 13,000 pounds.

SECTION XV

C-5A

4–71 GENERAL DESCRIPTION

The C-5A is a four-engine, high-wing, long-range heavy transport (Fig. 4–88). The planned commercial version of the C-5A is the Lockheed L-500. The C-5A is designed to transport palletized cargo and unpalletized bulk cargo, and to provide airdrop capabilities using components of the standard 463L Cargo Handling System. A removable troop compartment, located immediately aft of the wing spar and above the cargo envelope, provides seating and comfort facilities for 75 troops. Mixed airdrops of personnel and cargo can be accommodated.

The useful load of the C-5A is 409,531 pounds at design flight gross weight. The useful load at maximum design gross weight is 450,531 pounds. The maximum design gross weight of the aircraft is 769,000 pounds.

The C-5A is designed to be compatible with all existing and planned components of the 463L Cargo Handling System. The large rear opening and clean afterbody configuration with aft doors in the airdrop position make the aircraft ideally suited for low-altitude airdrop operations (par. 3–5). High lift devices on the wing and powerful engines provide the capability for low-altitude, low-speed flight. The airdrop potential ranges up to four 50,000-pound loads or ten 10,000-pound loads.

4–72 CARGO COMPARTMENT

The C-5A has a fixed cargo floor 228 inches wide and 1453 inches long, providing a floor area of 2300 square feet (Fig. 4–89). The forward and aft ramps provide

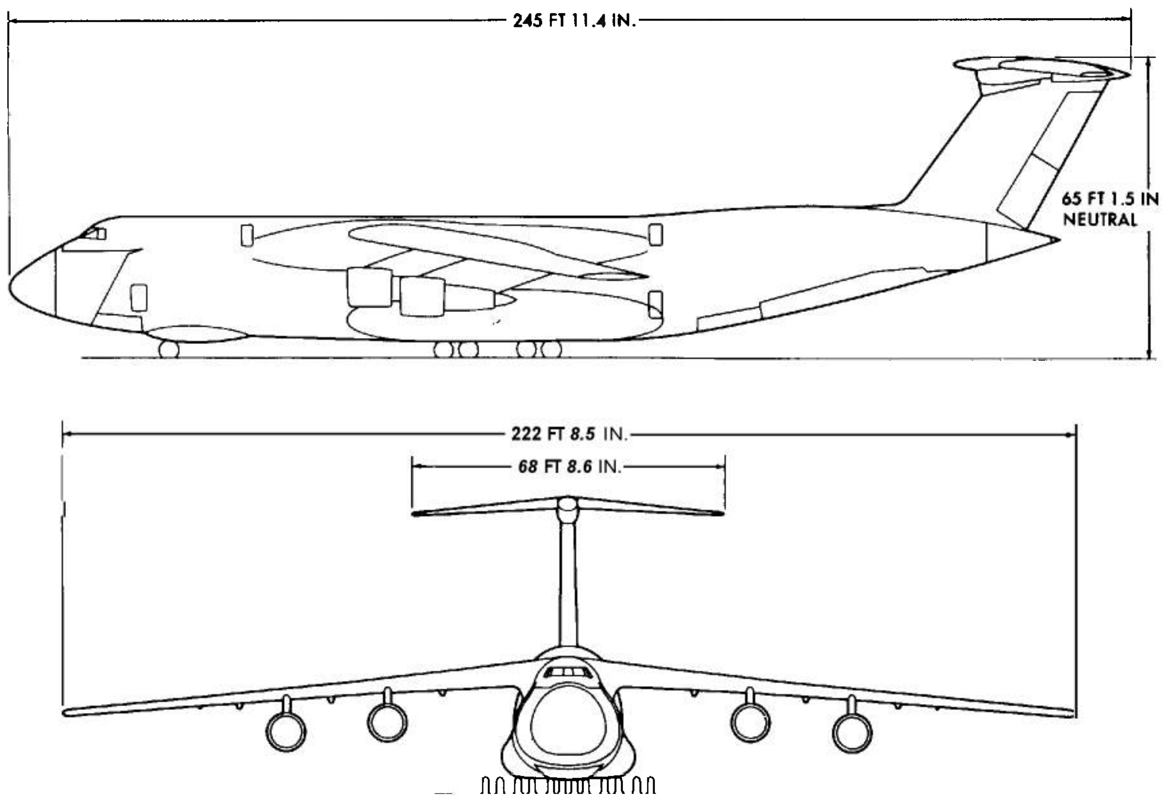


FIGURE 4–88. C-5A AIRCRAFT

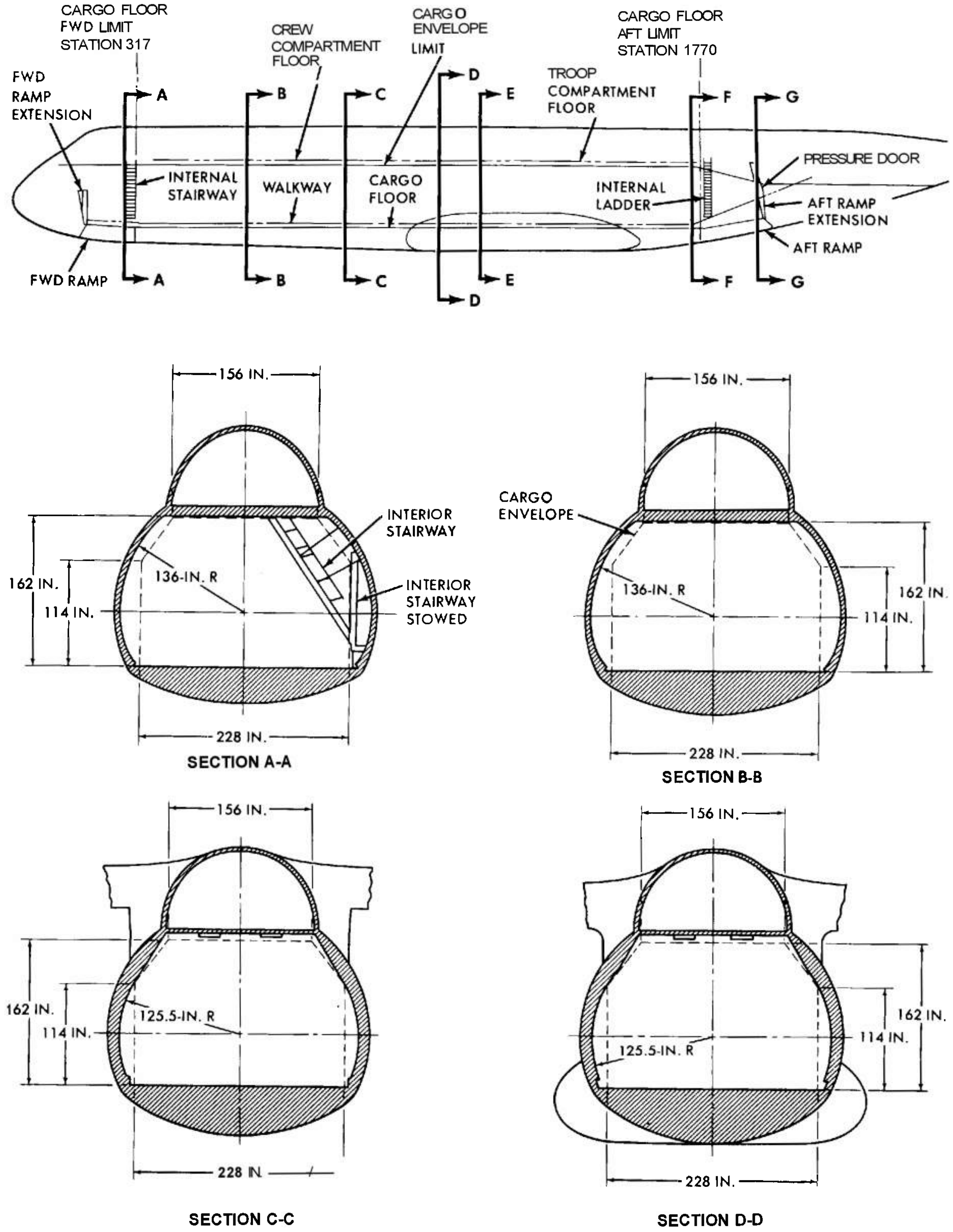


FIGURE 4–89. CARGO COMPARTMENT, C-5A AIRCRAFT (1 OF 2)

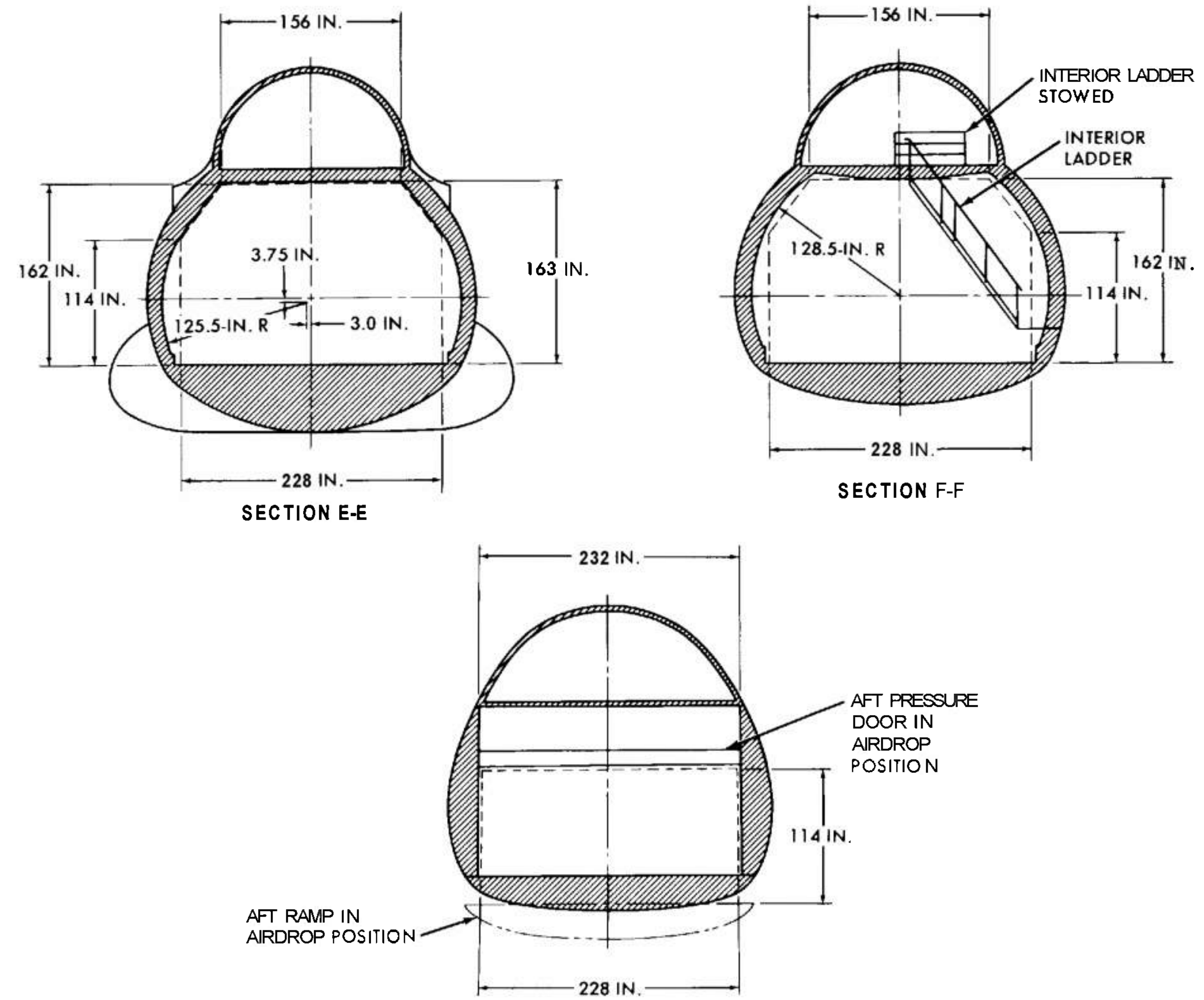


FIGURE 4–89. CARGO COMPARTMENT, C-5A AIRCRAFT (2 OF 2)

an additional usable loading area of approximately 435 square feet. In the air transport configuration, the cargo compartment will accommodate thirty-six 88-inch by 108-inch pallets, including two pallets each loaded on the forward and aft ramps. Vertical clearance along the side of the cargo **floor** is 114 inches, tapering to a 156-inch wide ceiling 162 inches above the **floor**. The troop compartment floor and interior ladder are removable to allow increased cargo payload. Troop positions may be provided in the cargo Compartment by the installation of palletized seats. Two **rows of five** abreast seats provide a seating capacity of 280 troops.

4–72.1 FLOOR LOADING. The forward ramp, cargo **floor**, and aft ramp are designed as load carrying structure for their full width, providing loading capability for vehicles with axle loads up to 25,000 pounds over any part of these surfaces without shoring (Fig. **4—90).** The cargo floor between fuselage stations 524 and 1684 is designed to accommodate inflight loads associated with 25,000-pound axle loads or 400 pounds per square foot. In the same area, two 18,000-pound axle loads may be restrained side by side. The remaining floor area is designed to carry one 14,000-pound axle load, two 10,000-pound axle loads side by side, **or** 300 pounds per square foot. The forward

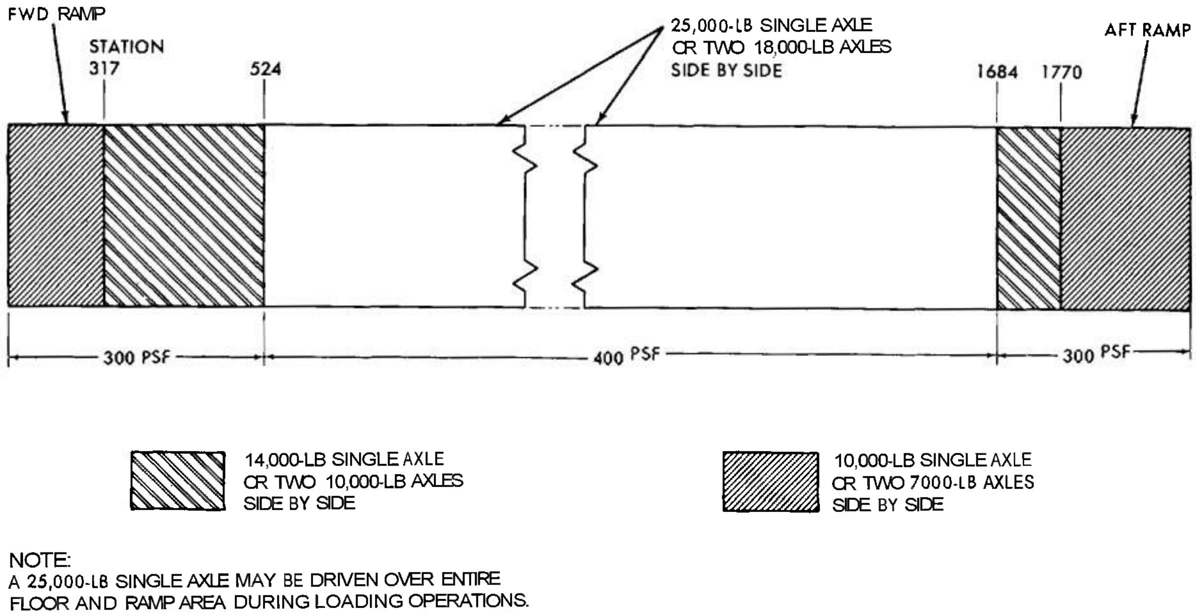


FIGURE 4-90. CARGO COMPARTMENT WEIGHT LIMITS, C-5A AIRCRAFT

and aft ramps are designed to carry one 10,000-pound axle load, two 7000-pound axle loads side by side, or 300 pounds per square foot. A maximum load of 10,375 pounds per pallet can be carried on 88-inch by 108-inch pallets secured on the cargo floor. A maximum load of 7500 pounds per pallet can be carried on 88-inch by 108-inch pallets secured on the forward and aft cargo ramps.

4–72.2 ANCHORING ARRANGEMENT. To facilitate restraint of wheeled and tracked vehicles and bulk cargo, 25,000-pound capacity tiedown receptacles are installed throughout the cargo floor and ramp area on approximately 40-inch center to center spacing (Fig. 4—91). These receptacles will accommodate 25,000-pound quick-disconnect tiedown fittings. The ring on each tiedown fitting is designed to accept the hook from one 25,000-pound MB-2 tiedown device or the hooks from two 10,000-pound MB-1 tiedown devices. Enough MB-1 and MB-2 devices are provided on the aircarft to restrain vehicular loads up to the maximum payload of the aircraft.

Two sets of logistic restraint rails are installed symmetrically about the centerline of the aircraft on the cargo floor. The rails are positioned to accommodate two rows of 88-inch by 108-inch pallets, with the 88-inch dimension in the fore-and-aft direction (Fig. 4—91). The outboard rail in each set of rails is permanently installed along the edge of the cargo floor. The inboard rails of each set may be rotated up for loading or rotated down to provide a smooth floor. Lateral restraint of pallets is provided by the inner face of the rails. Vertical restraint, throughout most of the cargo floor, is provided by fixed horizontal lips integral with the rails. At the forward and aft 60 inches of the cargo floor, retractable lips are used for vertical restraint. Longitudinal restraint is provided by lock mechanisms which operate through the outside rails.

Two sets of restraint devices are also provided on each ramp. These devices permit two pallets to be loaded and restrained on each ramp while the ramps are extended. The ramps can then be raised to the stowed position, with the load in place.

4–72.3 AIRDROP EQUIPMENT. In addition to the air transport rails and conveyors, the C-5A is equipped with an airdrop system consisting of restraint rails, roller conveyors, an extraction parachute system, and an anchor cable system. All components are provided in a transportable kit and can be stowed in the aircraft. Stowage pro visions for the restraint rails and roller conveyors are made along both sides of the cargo compartment over its entire length.

The restraint rails are attached to the cargo floor using quick-disconnect fittings which engage the 25,000-pound tiedown receptacles. Lateral restraint of loads is provided through the inner face of the rails. Vertical restraint is provided by the rails through a fixed horizontal integral lip, except at the aft end. At the aft end of the rails, a retractable lip mechanism provides clearance for the tipping action of the platform during airdrop. Longitudinal restraint is provided by restraint mechanisms installed in the left-hand rail. These restraint mechanisms are designed to provide the required positive forward restraint and the variable aft restraint necessary to control an airdrop load up to 50,000 pounds. Remote control of the restraint mechanisms is provided to permit preselected arming for sequential airdrop as well as emergency release of the airdrop load.

Four rows of roller conveyors with high-speed rollers are installed on the cargo floor and aft ramp, between the restraint rails. The conveyors are attached with quick-disconnect fittings and are designed to withstand the speeds and loads developed by airdrop of a 50,000-pound load on a platform released from the forward end of the cargo floor under an extraction force of 1.5 g's.

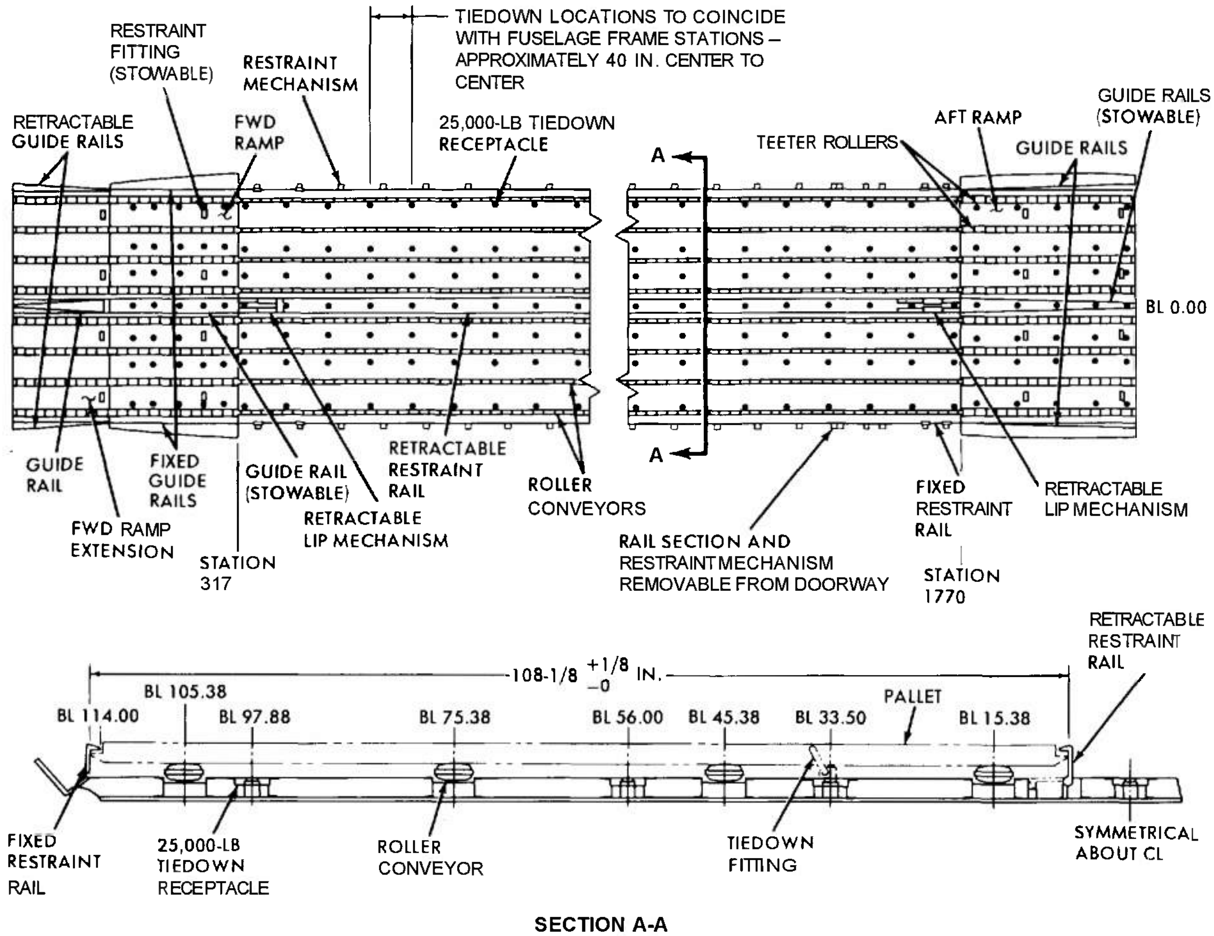


FIGURE 4-91. ANCHORING ARRANGEMENT, C-5A AIRCRAFT

The extraction parachute system, including electrical and manual controls, is permanently installed in the aircraft with the exception of that part of the system which attaches to the pressure door. Because of the design of the pressure door, the extraction parachute device and parachute can be installed and rigged at floor height, then by opening the pressure door the parachute is rigged for airdrop. An extraction line retention device is installed in the surface of the aft ramp to provide pre-tension on the extraction line and eliminate line whip resulting from turbulent air around the aft end of the aircraft when the cargo door is open. Additional fittings are provided which may be installed in any of the tiedown receptacles and used to secure the extraction line with breakcord.

The anchor cables are attached near the forward end of the cargo compartment to brackets installed on the compartment sides and at the aft end to brackets installed on the pressure door. With the pressure door closed, tension is retained on the anchor cables by support brackets located at the door hinge line. The anchor cables are employed for use automatically when the pressure door is opened.

4-73 CARGO DOORS AND RAMPS

4-73.1 FORWARD CARGO DOOR AND RAMP. The C-5A has a visor-type forward cargo door which provides an effective opening equal to a cross section of the cargo compartment (Fig. 4-92). Deployment of the forward ramp and forward ramp extension provides a 228-inch by 271-inch loading platform for loading from the ground, and a 228-inch by 212-inch platform for loading from truck bed heights of 36 to 72 inches or straight-in loading, at heights of 54 and 71.6 inches above the ground.

4-73.2 AFT CARGO DOORS AND RAMP. The aft cargo doors consist of a pressure door, a center door, and two side doors (Fig. 4-93). The pressure door can be hinged at the top — to the fuselage — and folded out of the way for straight-in loading or airdrop; or alternately, through the use of a hydraulically operated interlocking mechanism, it can be hinged at the bottom — to the aft cargo ramp — and folded down as a ramp extension. The aft cargo ramp can be deployed and held at any position from stowed to a position inclined 13.5 degrees below the cargo floor. Deploying the ramp with the pressure door used as a ramp extension provides a loading platform 228 inches wide and 325.5 inches long. A vertical clearance of 150 inches is provided with the, ramp positioned for ground loading. The horizontal clearance is 228 inches with all doors open or 156 inches with the side doors closed (positioned for airdrop). Vertical clearance for straight-in loading or airdrop is 114 inches.

4-74 RESTRAINT CRITERIA

As a result of placing personnel above the cargo envelope, a general 3.0 g cargo restraint load factor is being utilized.

4-75 CARGO LOADING AND UNLOADING PROVISIONS

4-75.1 AIRCRAFT KNEELING AND STABILIZATION SYSTEM. The C-5A landing gear is designed to allow the aircraft to be kneeled to facilitate loading (Fig. 4-94). With the aircraft in the forward kneeled position, simultaneous off the ground loading can be accomplished into both ends of the aircraft with the forward ramp inclined 11 degrees, the aft ramp inclined 13 degrees, 30 minutes, and the cargo floor inclined aft at less than 1 degree. The aircraft can be positioned to provide straight-in loading at heights of 54 and 71.6 inches and truck bed loading at heights of 36 to 72 inches above the ground. The C-5A landing gear incorporates provisions to level the kneeled aircraft laterally to compensate for a 3-percent grade when loading on sloping terrain.

4-75.2 CONVEYOR SYSTEM. Eight rows of roller conveyors are installed across the forward and aft ramps and the full length of the cargo floor with four rows located

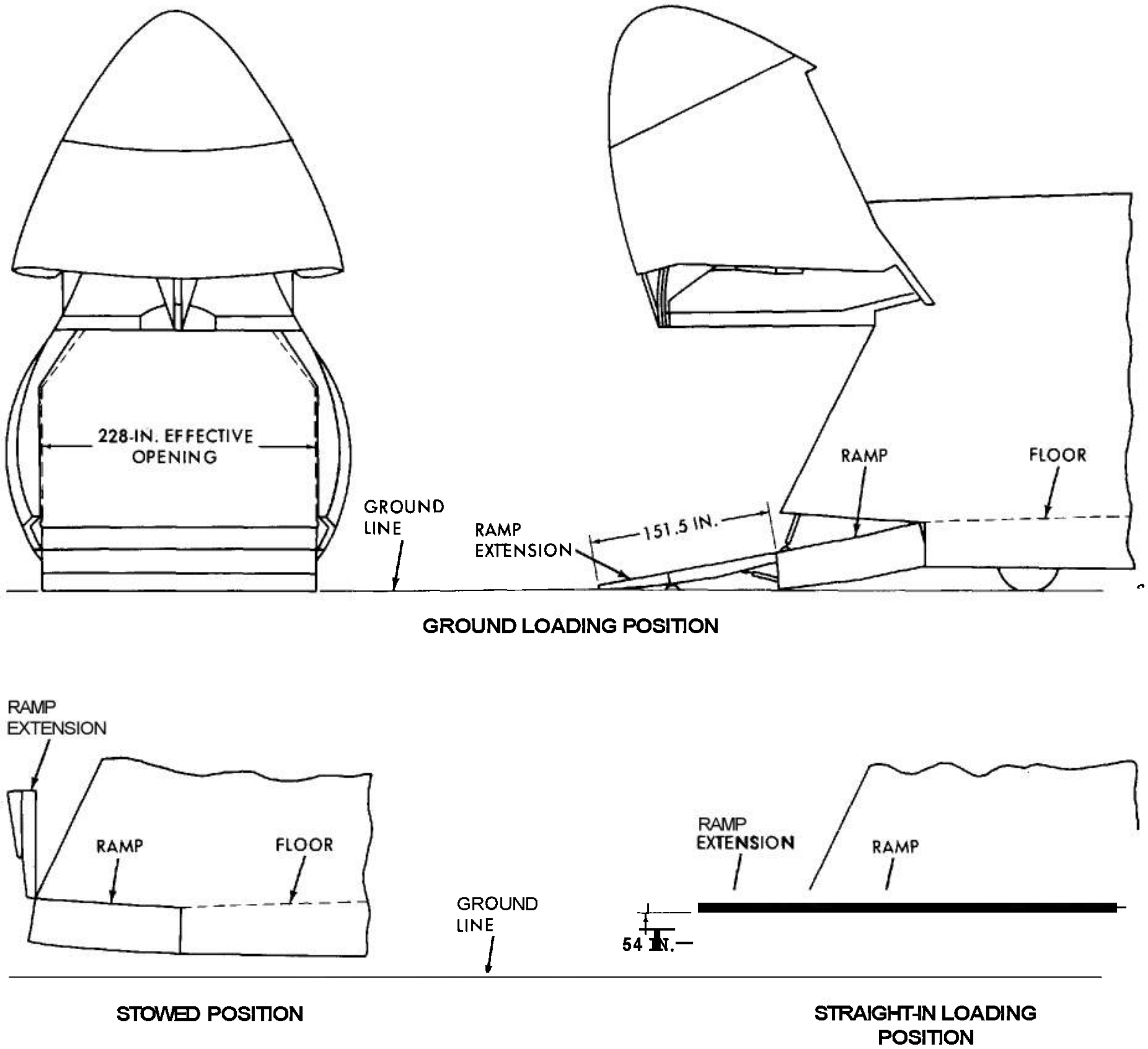


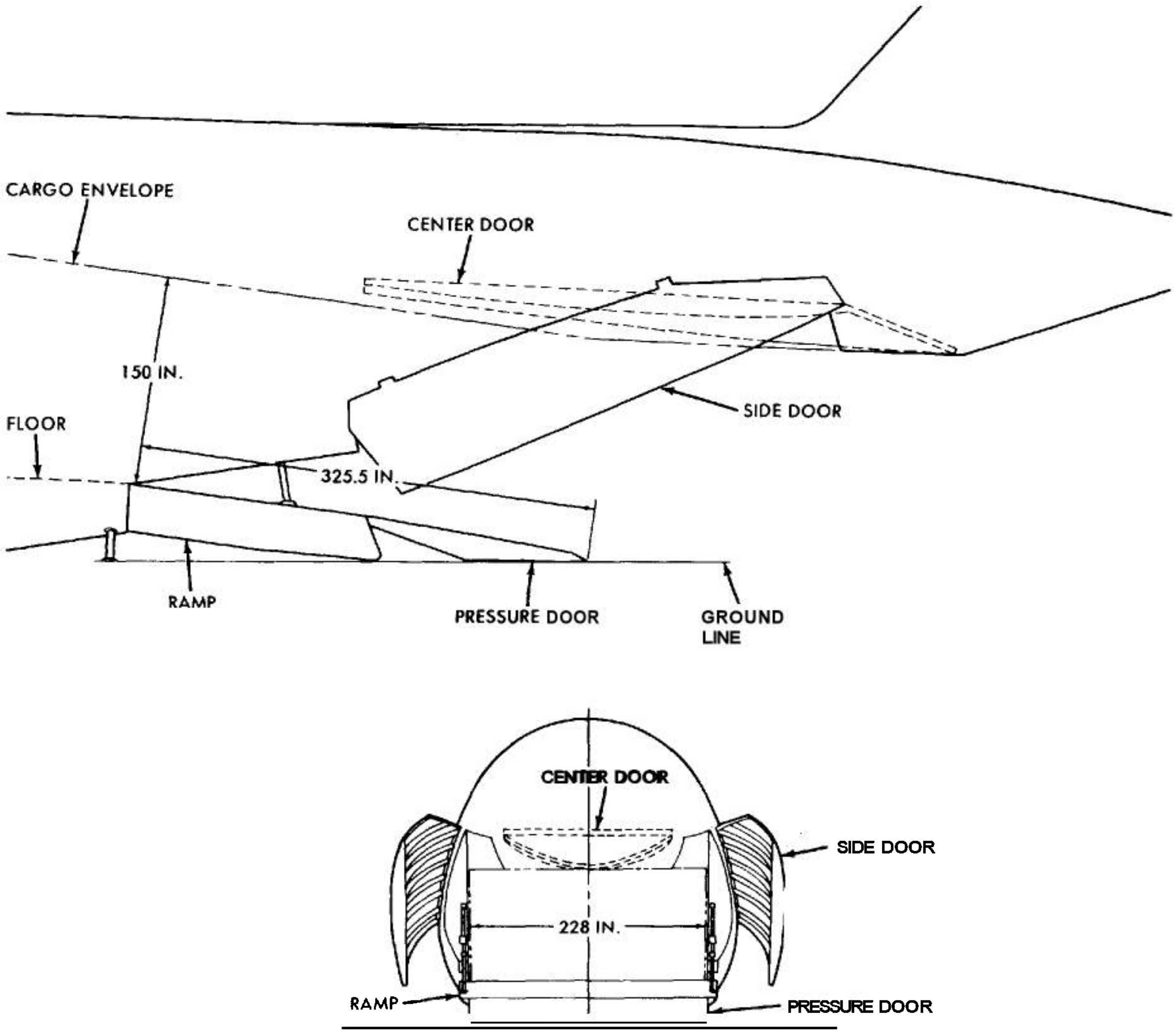
FIGURE 4–92. FORWARD CARGO DOOR AND RAMP, C-5A AIRCRAFT

between each set of restraint rails. The rollers across the forward ramp extension and the aft ramp are designed to permit lateral movement of pallets. Heavy-duty teeter rollers are installed as the last roller on the forward ramp, the first and last rollers on the cargo floor, and the first roller on the aft ramp (Fig. 4–91).

4–75.3 CARGO WINCH. Provisions for installation of a cargo winch are provided in both forward and aft ramps. A cargo winch, installed in either of these locations, can accomplish winching at any point in the aircraft by using a snatch block installed in a 25,000-pound tiedown receptacle.

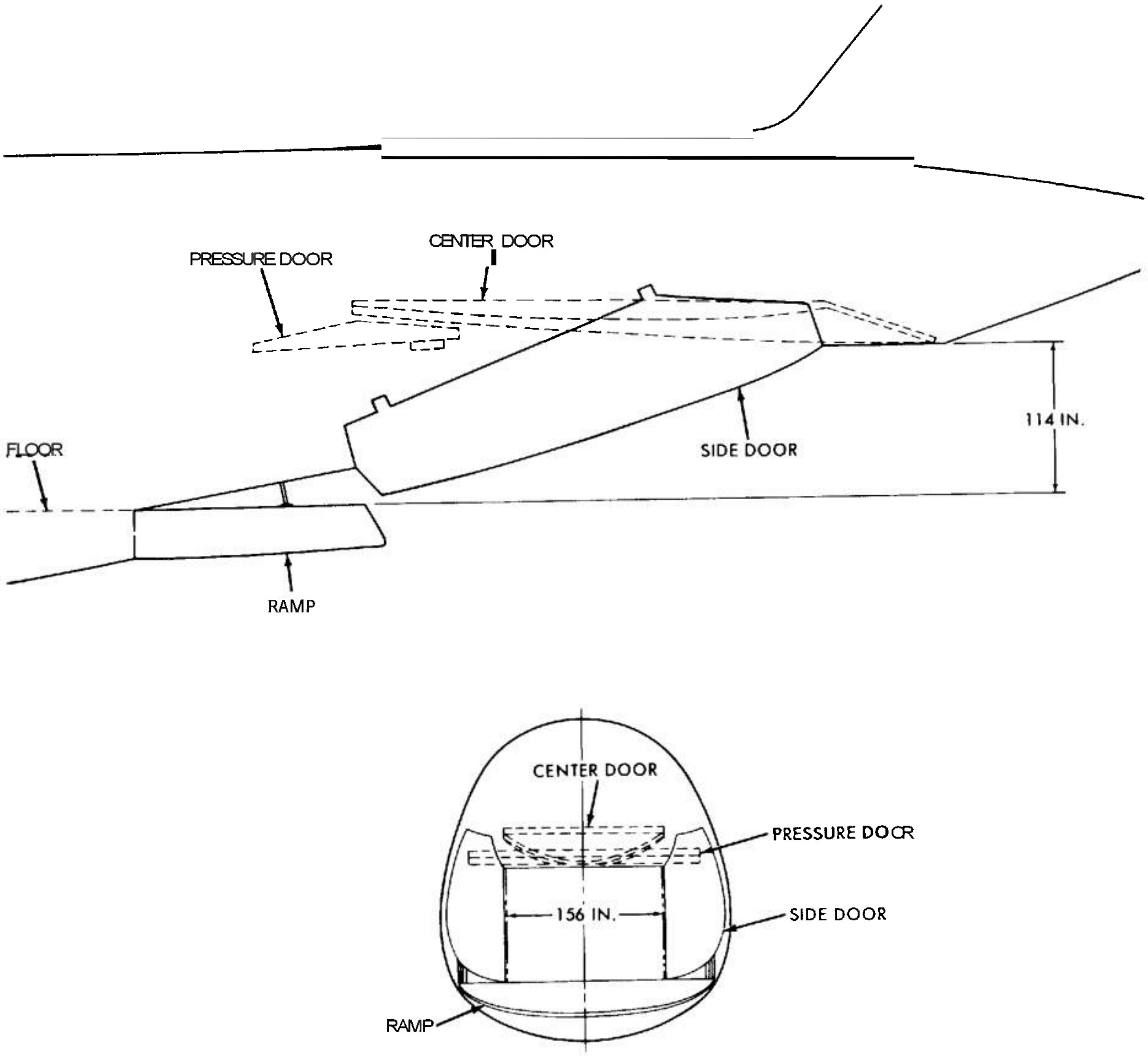
4–75.4 CARGO CONTROL SYSTEM. During loading and unloading with the cargo floor on an incline, the load may be free to move should a winch cable break or a loader lose his footing. Under these conditions, a restraint cable is installed along the top of the floor with the ends attached to each ramp. A restraint device is attached to the pallet being moved and placed over the cable. The restraint device will clamp on the cable in the event of a load reverse or when tension on the lanyard is released.

4–75.5 AIRDROP SYSTEM LOADING PROVISIONS. Airdrop platforms up to 28 feet in length and with maximum rated loads can be loaded in the aircraft. Straight-in loading of pallets or platforms can be accomplished at both ends of the aircraft at heights of 54 and 71.6 inches above the ground. Truck-bed loading can be accomplished into both ends of the aircraft at heights of from 36 to 72 inches above the ground. Off the ground loading of 463L pallets can be accomplished into both ends of the aircraft when in the forward or level kneeled positions (Fig. 4–94). Off the ground loading can be accomplished into the aft end of the aircraft when in the aft kneeled position. The cargo ramps are designed to support two 40,000-pound, 28-foot platforms being loaded simultaneously under a load factor of 1.33 g's.



DOORS POSITIONED FOR GROUND LOADING – AIRCRAFT IN AFT KNEELING POSITION

FIGURE 4–93. AFT CARGO DOORS AND RAMP, C-5A AIRCRAFT (1 OF 2)



DOORS POSITIONED FOR STRAIGHT-IN LOADING OR AIRDROP

FIGURE 4-93. AFT CARGO DOORS AND RAMP, C-5A AIRCRAFT (2 OF 2)

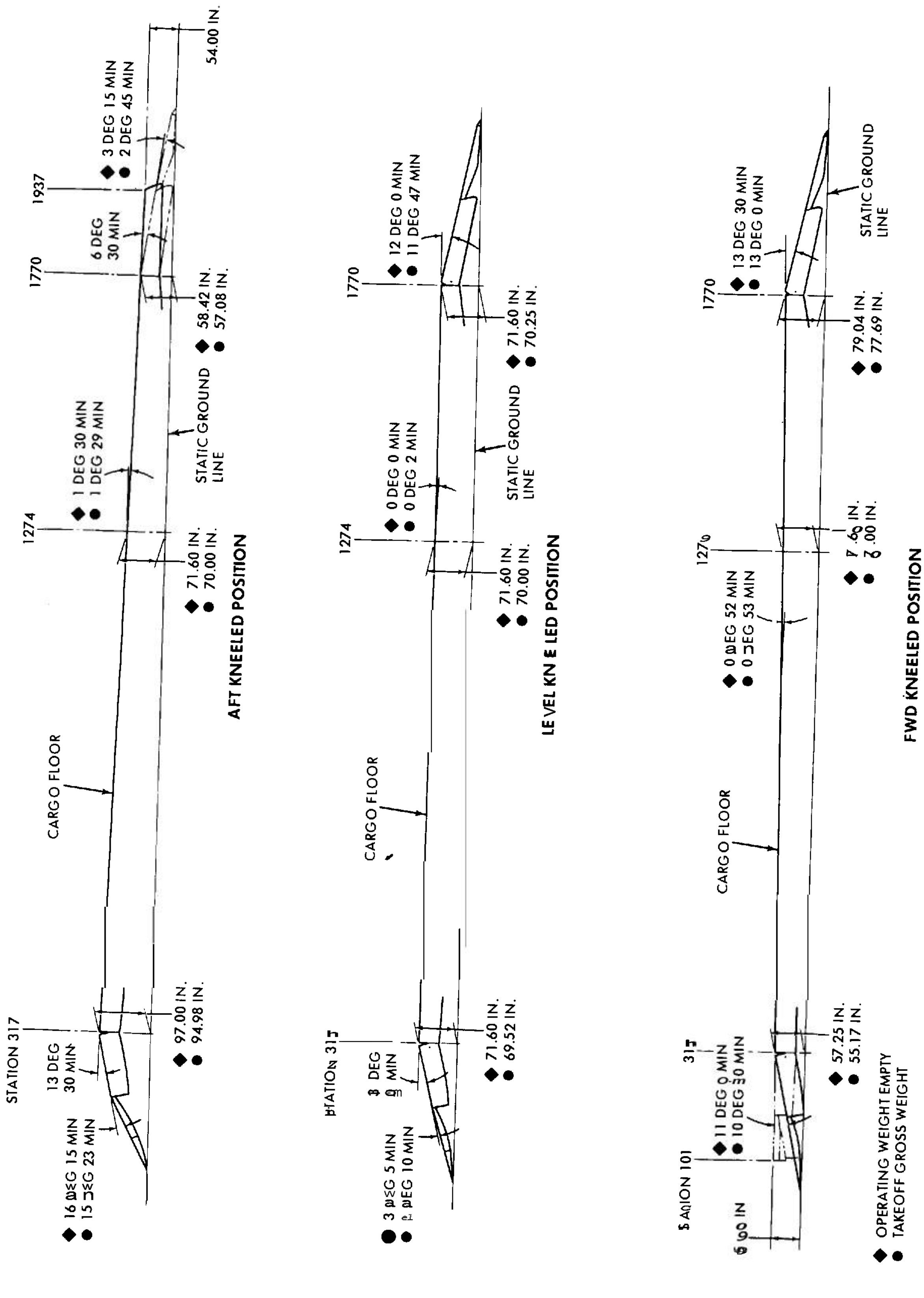


FIGURE 4-94. AIRCRAFT KNEELING POSITIONS, C-5A AIRCRAFT

SECTION XVI

CV-2

4–76 GENERAL DESCRIPTION

The **CV-2** is a high-wing, twin-engine, short takeoff and landing (STOL) transport designed for passenger or cargo carrying, paratrooper or airdrop, or for casualty evacuation (Fig. 4–95). The aircraft contains a power-operated cargo door and ramp which, in conjunction with the upswept aft fuselage, permit direct cargo loading. For airdrop purposes, the aircraft is designed so that supplies and equipment rigged on platforms or in containers may be dropped by the extraction, gravity, or manual ejection methods from the rear of the cargo compartment. Small containers or packages may also be manually ejected from the aircraft passenger doors.

4–77 CARGO COMPARTMENT

The cargo compartment is **345** inches long, **73-1/2** inches wide (at floor level), and **74** inches high. The compartment floor is **45** inches from the ground. Dimensions and contours of the cargo compartment are shown in Fig. **4–96.** Loads rigged on platforms, for extraction or gravity release, cannot exceed **61-1/4** inches in height (measured from the bottom of the platform), 70 inches in width, and **144** inches in length. Roller conveyors used in the air delivery system consist of standard and modified sections of skate-wheel conveyors conforming to Military Specification MIL-C-5927B, Style 11. Eight conveyor sections are utilized, consisting of four standard

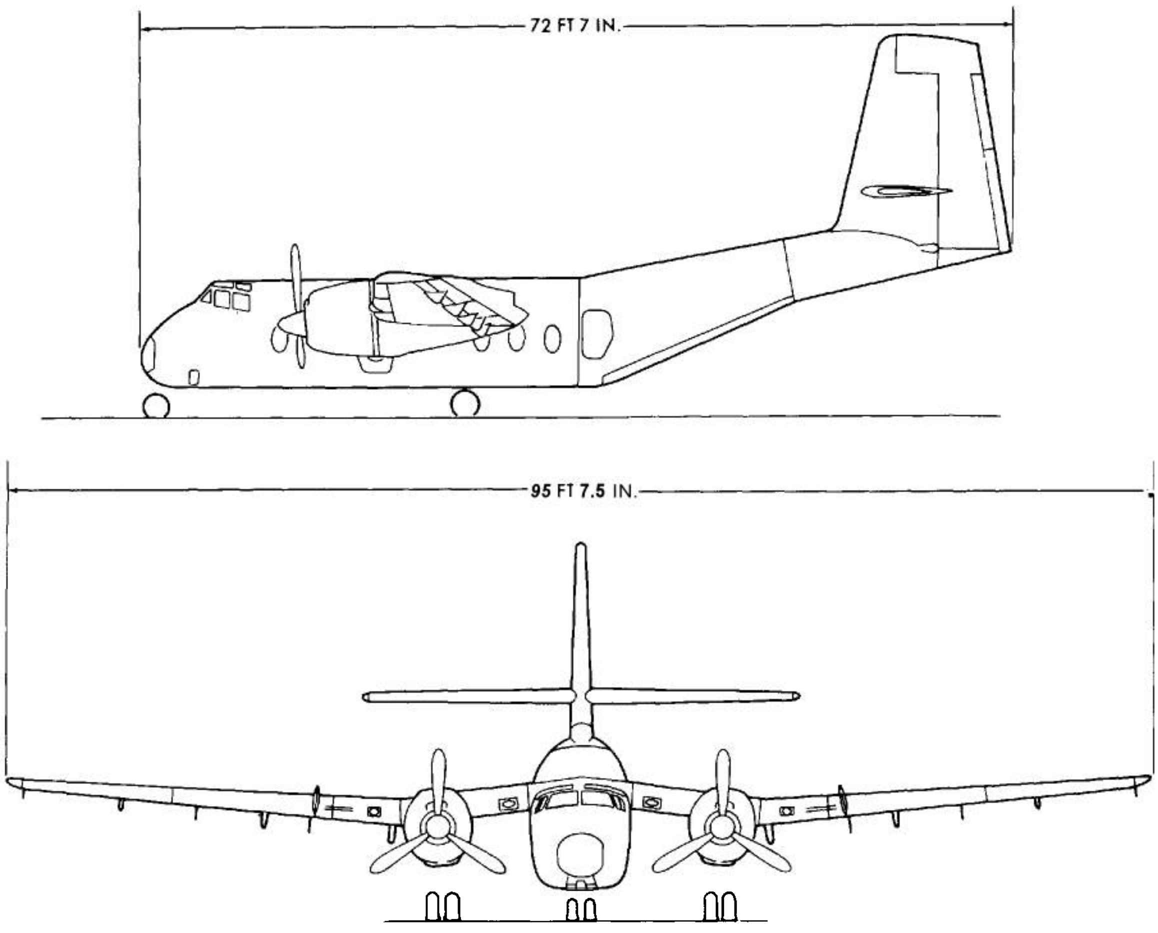


FIGURE 4–95. CV-2 AIRCRAFT

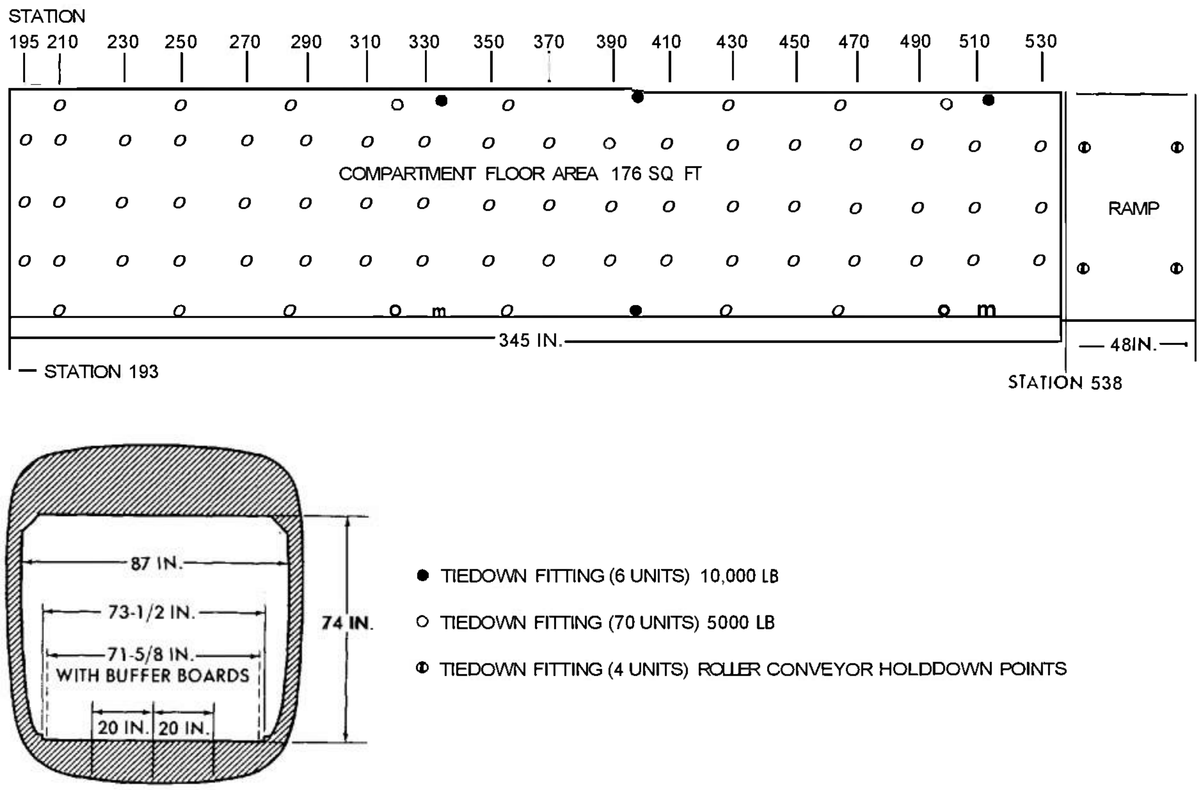


FIGURE 4-96. CARGO COMPARTMENT DIMENSIONS AND ANCHORING ARRANGEMENT, CV-2 AIRCRAFT

120-inch lengths, two 98-inch lengths, and two 43.5-inch lengths. All sections are 12 inches wide and, when installed in two rows, extend the length of the cargo compartment.

4—77.1 FLOOR LOADING. The cargo floor is of aluminum alloy honeycomb sandwich construction. Removable plywood panels, with skid strips to facilitate cargo handling, are provided for the floor protection. The floor supporting structure consists of three continuous longitudinal keels which occupy the space between the floor and the outside section. The keels will act as skids in the event of a wheels-up landing.

The cargo floor will not withstand the same load over its entire area because of the design strength of the fuselage. The honeycomb paneling is designed to withstand 40 pounds per square inch at any point. While the paneling itself may withstand the load, the fuselage strength may be exceeded. Therefore, the local footprint pressure of individual load items must not exceed 1000 pounds per square foot, while at the same time a loading of 1200 pounds per running foot must not be exceeded. Bulk weight which exceeds either of these limits must be shored in order to spread the weight over a larger area.

The loads on the vehicle treadways must not exceed 2000 pounds per wheel during loading and unloading. This is also the maximum wheel loading on the treadway forward of station 397.6 during takeoff, flight, and landing. The treadway area aft of station 397.6, during takeoff, flight, and landing, and the remainder of the floor area under all conditions should not exceed 1000 pounds per wheel. The designated cargo and treadway areas are shown in Fig. 4—97.

4—77.2 ANCHORING ARRANGEMENT. Seventy-six tiedown fittings are provided in the cargo compartment flooring (Fig. 4—96). Seventy of these fittings have a restraint capacity of 5000 pounds, and six have a restraint capacity of 10,000 pounds. A recess at each fitting allows clearance for the tiedown device. These fittings are also used to secure the roller conveyors in place, and four additional flush-mounted fittings for roller conveyors are located in the ramp.

A 78 CARGO DOORS AND RAMPS

The aft end of the cargo compartment is formed by a large cargo door, which hinges upward, and a ramp, which is an extension of the cargo compartment floor (Fig. 4—98). With the ramp in the horizontal position, cargo may be loaded into the aircraft directly from standard cargo vehicles. Ramp extensions are also provided to extend the ramp to the ground for troop or mobile equipment entrance. The cargo door and ramp are operable in flight for airdrop of personnel or supplies and equipment. Two passenger doors, one on each side of the cargo compartment, are located slightly forward of the cargo door.

The two ramp extensions are 120 inches long and 15 inches wide and are stowed in special racks above the cargo door. The ramp extensions are reversible and both sides have nonskid surfaces. One side is provided with edge members for use with wheeled vehicles, while the other side has a flat surface to facilitate cargo movement when using rollers.

The passenger doors, with bottom sills 11 inches from the floor, are 55 inches high, and the width ranges from 16 inches at the bottom, 32-3/4 inches at the middle, and 28 inches at the top. Door package sizes must not exceed 40 inches in length, 24 inches in width, and 36 inches in height.

4—79 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the CV-2 aircraft:

Forward	8.0
Side	1.5
Aft	2.0
Vertical	2.0

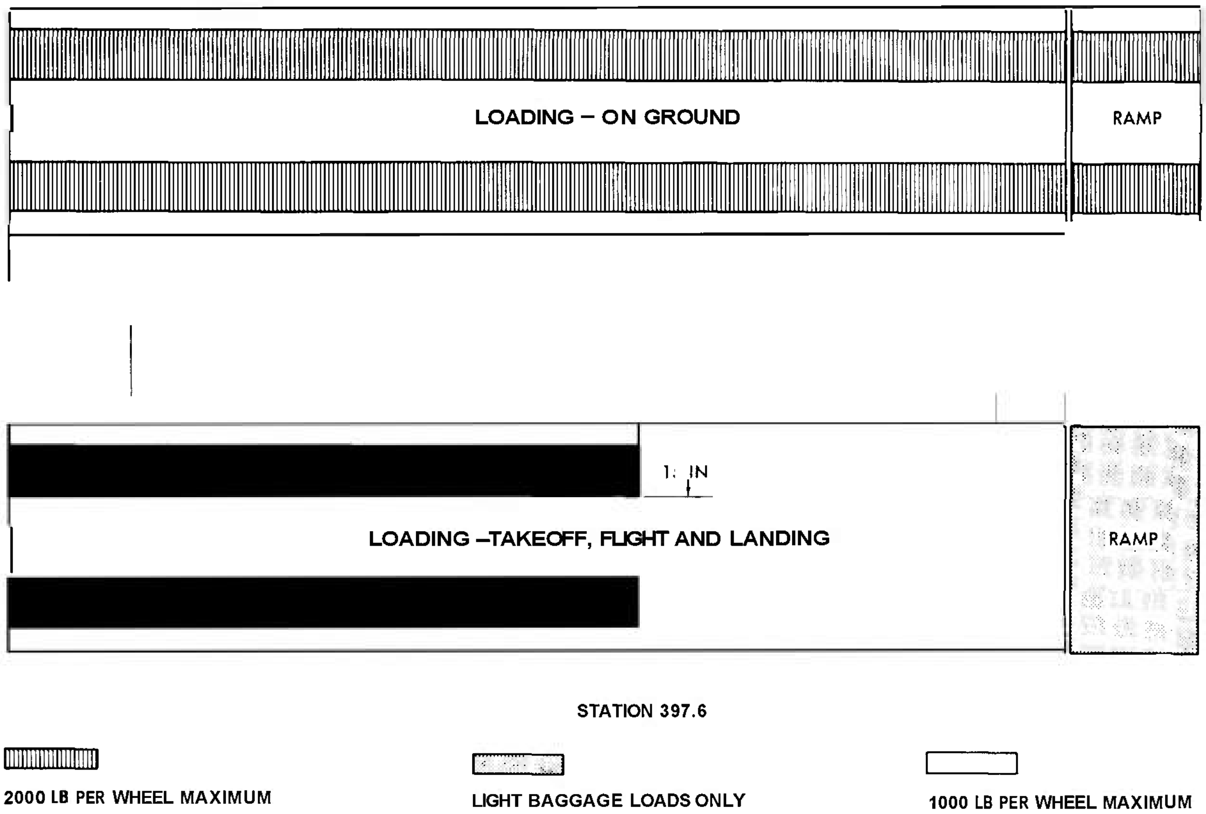


FIGURE 4-97. CARGO AND TREADWAY AREAS, CV-2 AIRCRAFT

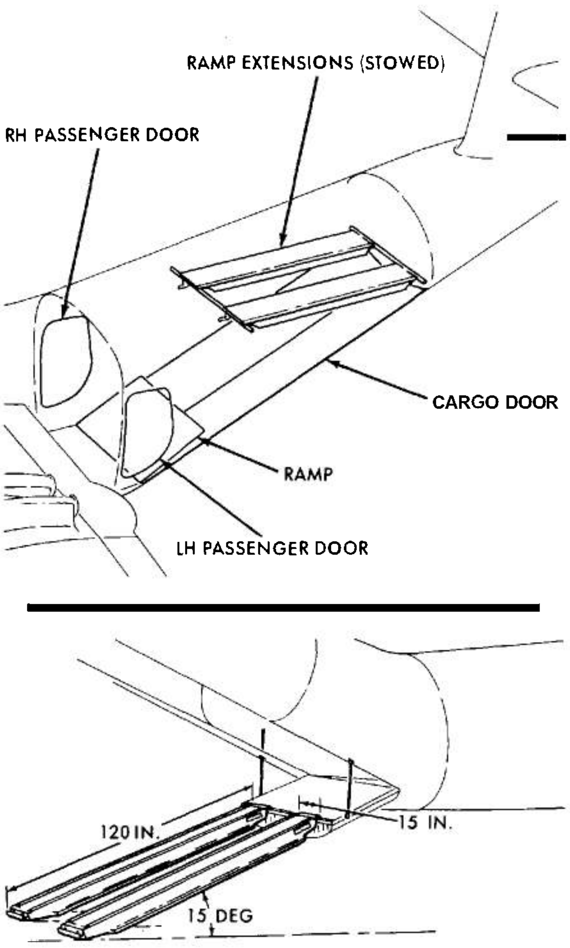


FIGURE 4–98. CARGO DOORS AND RAMPS, CV-2 AIRCRAFT

4–80 CARGO LOADING AND UNLOADING PROVISIONS

A corrugated web structure supporting an extended carrier member runs the length of the cargo compartment roof. The structural provisions are for a monorail crane assembly with a 2000-pound capacity.

Stowable ramp extensions are normally carried in the aircraft. The ramp extensions facilitate ground-to-aircraft loading of cargo and allow wheeled vehicles to drive in under their own power.

A fuselage steady strut, consisting of a base plate and a locking nut and tube assembly incorporating a screw thread, may be utilized to prevent the aircraft from tipping during loading procedures.

SECTION XVII

CV-7A

4-81 GENERAL DESCRIPTION

The **CV-7A** (Fig. 4—99) is a twin-engine, turbine-powered, short takeoff and landing **(STOL)** transport. It is equipped with stowable roller conveyors and a side guidance rail system, built as part of the aircraft. Also included in the aircraft is an aerial delivery kit consisting of anchor line cables and a pendulum release system. The **CV-7A** is capable of airdropping a single airdrop load of **7500** pounds and multiple drops up to the maximum allowable cargo load of 11,450 pounds.

4-82 CARGO COMPARTMENT

The cargo compartment affords an area **373** inches long, a maximum height of **78** inches, a width of 92.5 inches **(88.25** inches with side rail restraint system installed), and has a volume of 1560 cubic feet. Height of the cargo floor above the ground is 46 inches. The cargo handling system will accommodate **463L** notched pallets **88** inches wide, in lengths of 54 and 108 inches. Up to five **88-** by 54-inch or three **88-** by 108-inch pallets or platforms can be accommodated on the cargo handling system.

4—82.1 FLOORLOADING. The cargo floor extends the length of the cargo compartment. The floor is designed to withstand bulk cargo loads of **200** pounds per square foot, 1500 pounds per running foot, or a concentrated load (local footprint pressure

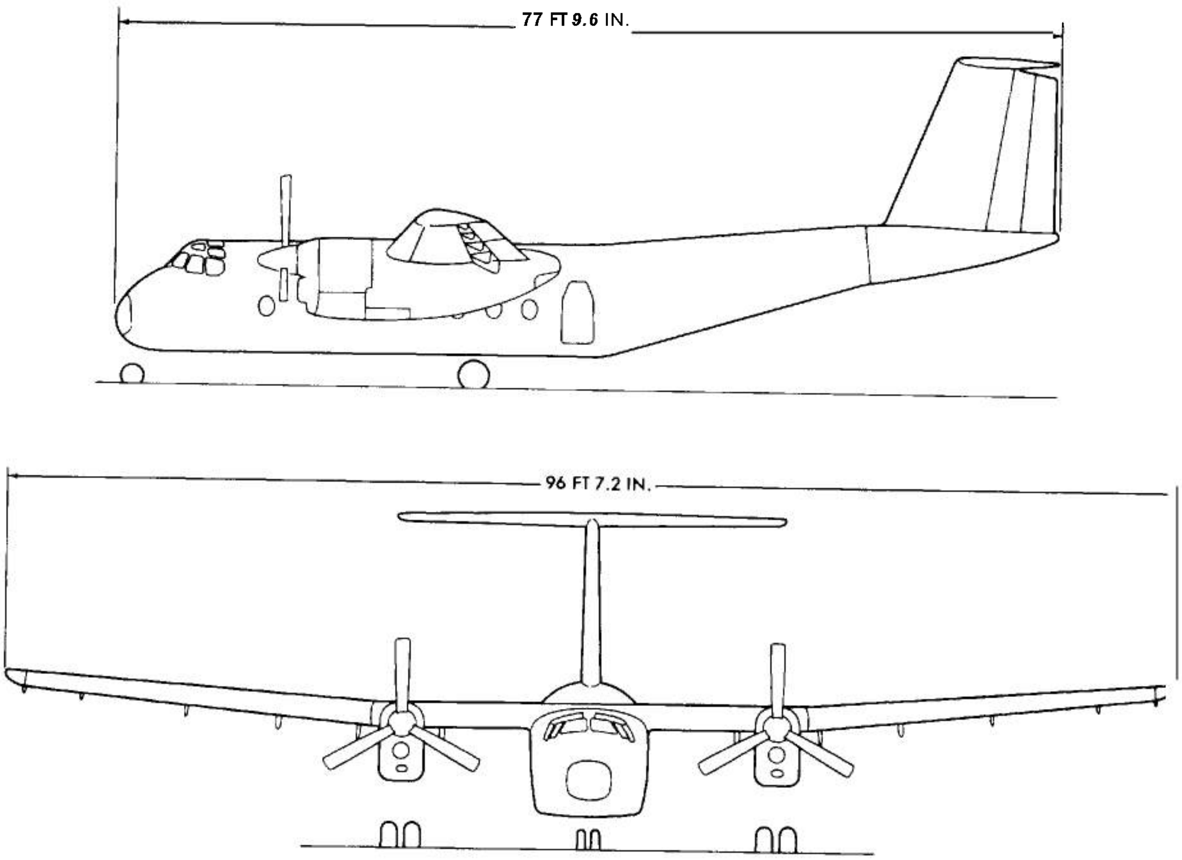


FIGURE 4–99. CV-7A AIRCRAFT

loads) of 1000 pounds per square foot. Treadway loads may not exceed 6000 pounds per axle or 3000 pounds per wheel (2000 pounds per wheel on the inner 4 inches of treadway).

4–82.2 ANCHORING ARRANGEMENT. A total of 77 tiedown rings are provided in the cargo floor and wall. Sixty-nine of these are 5000-pound capacity fittings installed in the floor. Two 10,000-pound capacity cargo fittings are also installed in the floor. Six 10,000-pound capacity tiedown rings are installed in the wall, 4 inches above the floor.

4-83 CARGO DOORS AND RAMPS

The aircraft is provided with a rear cargo door and ramp configuration that is electrically actuated. The door and ramp provide an opening approximately 68 inches high, 92.1 inches wide at the ramp hinge, and 82.3 inches wide at the door hinge for cargo loading. The ramp forms an angle of 15 degrees with the ground when lowered. Both door and ramp may be opened in flight.

4–84 RESTRAINT CRITERIA

No information available.

A 5 CARGO LOADING AND UNLOADING PROVISIONS

Stowable ramp extensions are normally carried in the aircraft. The ramp extensions facilitate ground-to-aircraft loading of cargo and allow wheeled vehicles to drive in under their own power.

SECTION XVIII

U-1

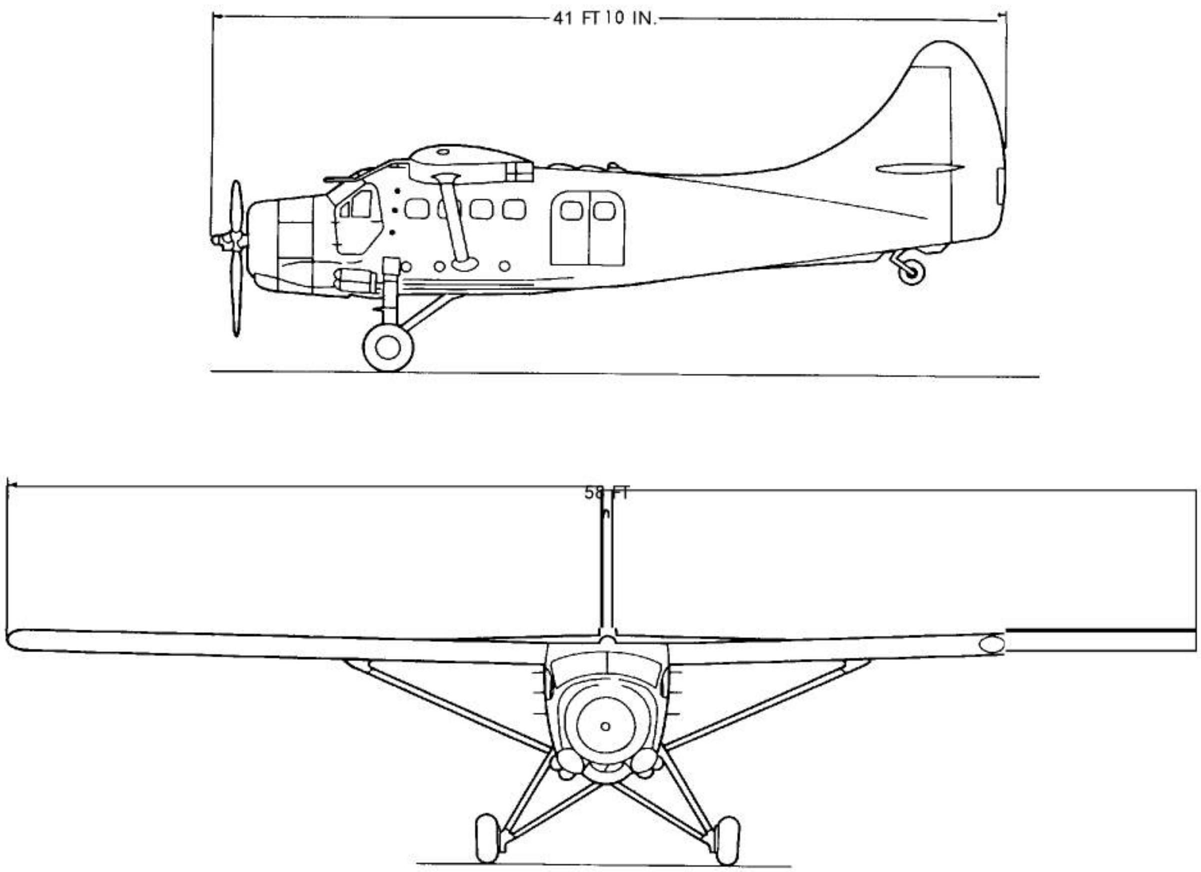
4—86 GENERAL DESCRIPTION

The **U-1** is a single-engine, high-wing aircraft with fixed conventional landing **gear** (Fig. 4—100). It is a utility aircraft and its mission includes carrying of light cargo, air delivery of small packages, medical evacuation, and liaison. Six litter patients can be transported on the U-1 aircraft. It has a useful load capacity of 3100 pounds, with a maximum allowable gross weight of ***8000*** pounds.

4—87 CARGO COMPARTMENT

The **U-1** has two separate compartments for carrying cargo: the main cargo compartment and the baggage compartment. The main cargo compartment extends from station **111.0** to station **264.0** and has a volume of **286.0** cubic feet. The baggage compartment extends from station **264.0** to station **308.0** and has a volume of 70.0 cubic feet. Critical contour of the main cargo compartment is shown in Fig. **4—101.**

4-87.1 FLOORLOADING. The main cargo compartment floor is an aluminum honeycomb, sandwich-type structure which provides a rigid surface. The main cargo compartment floor will support a uniformly distributed load of 150 pounds per square foot outboard of longitudinal reinforcing strips and 50 pounds per square foot inboard of reinforcing strips (load scheme 1, Fig. **4—102),** or an overall uniformly distributed load of 100 pounds per square foot (load



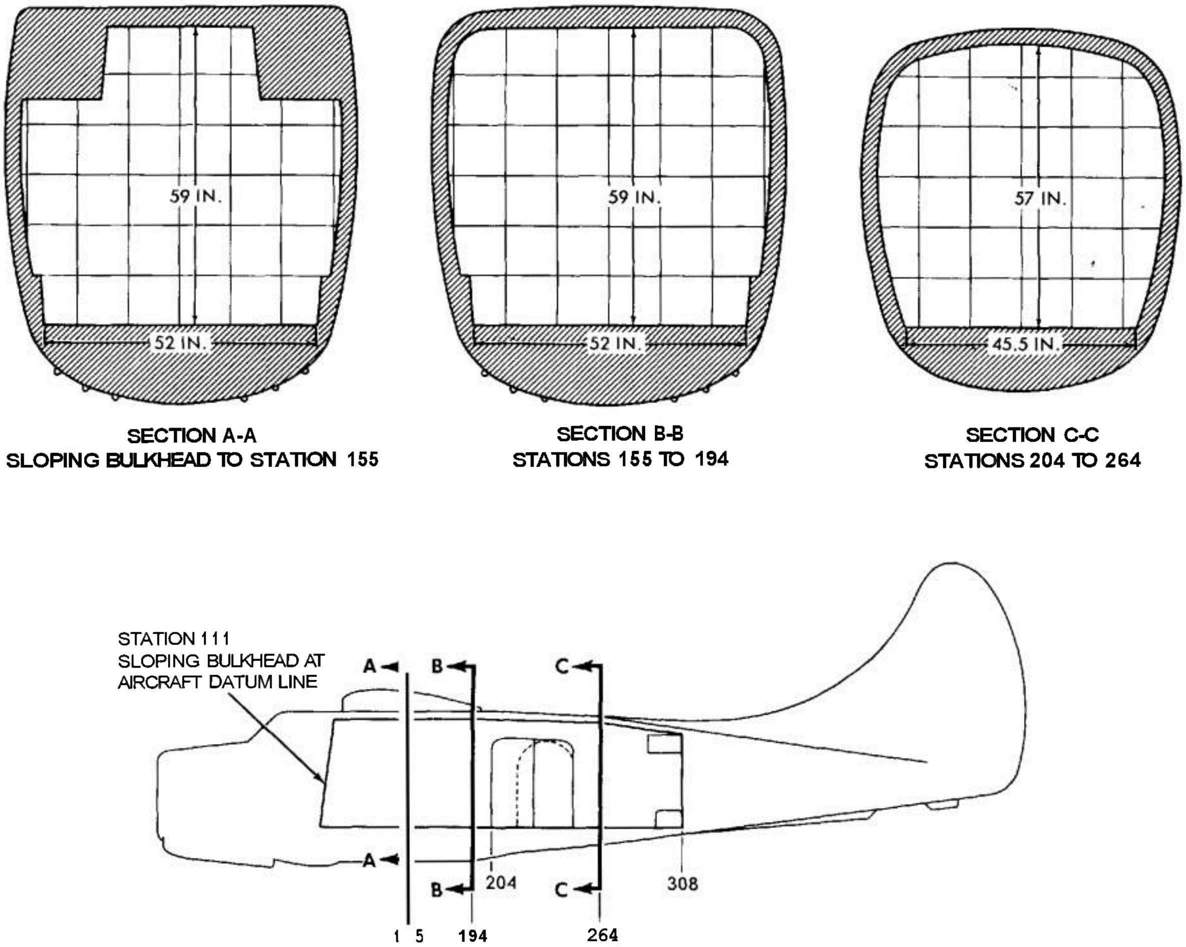


FIGURE 4-101. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, U-1 AIRCRAFT

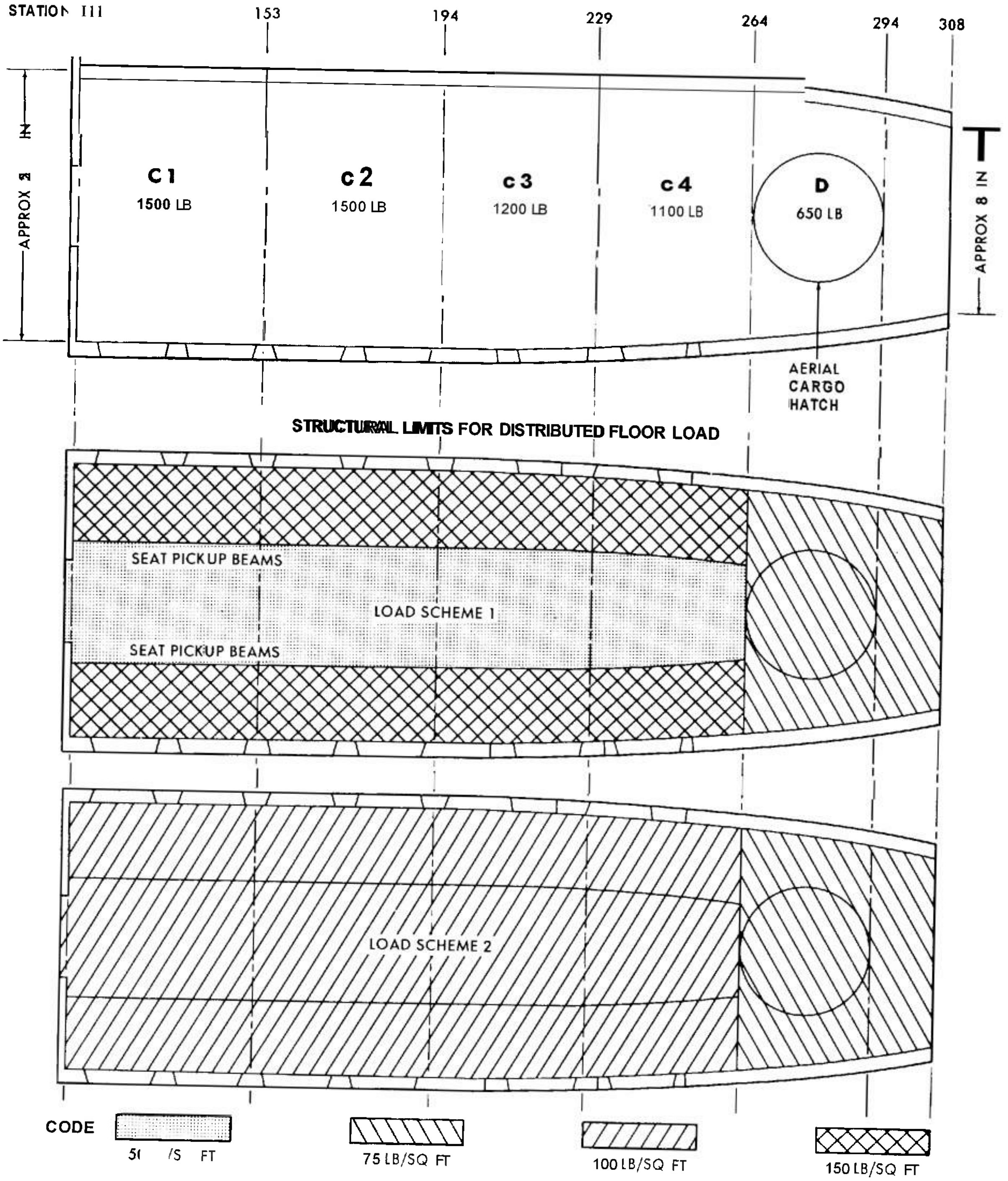
scheme **2)**. Concentrated loads shall be distributed so that a local static load of ***200*** pounds per square foot is not exceeded. The baggage compartment floor is constructed from swaged Alclad sheet and will support uniformly distributed loads of 75 pounds per square foot.

4-87.2 ANCHORING ARRANGEMENT. The location of the tiedown fittings is shown in Fig. 4—103. Ten of the tiedown fittings, coded A, B, C, D, and F, are permanently installed. The 18 tiedown fittings coded E are removable and can be installed in any of 35 receptacles on the heating ducts and floor. Each of the tiedown fittings has an ultimate load strength of 2000 pounds.

4-88 CARGO AND PASSENGER DOORS

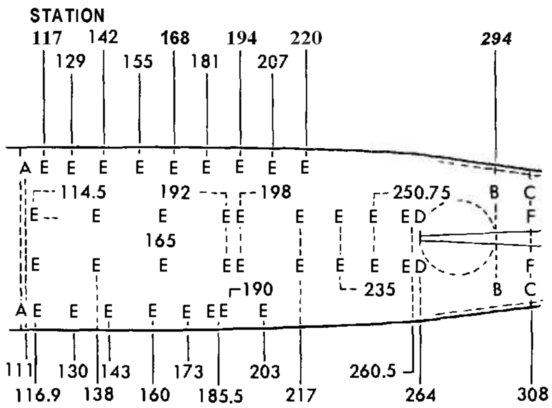
4—88.1 MAIN CARGO DOORS. The main cargo doors are **46.5** inches high by **45** inches wide. They are located on the left side of the fuselage and are primarily used for loading and unloading cargo or casualties (Fig. **4—104).** If the main cargo doors are used to load or unload personnel, **only** the forward cargo door need be opened. On aircraft serial No. 59-2009 and subsequent, the forward cargo door is jettisonable. Maximum package size that can be loaded through the main cargo door is shown in Table **4—10.**

4—88.2 AERIAL CARGO HATCH. The aerial cargo hatch is located between stations **264.0**



THE CABIN FLOOR WILL WITHSTAND LOCAL STATIC LOADS OF 200 LB/SQ FT

FIGURE 4-102. CARGO COMPARTMENT WEIGHT LIMITS, U-1 AIRCRAFT



FITTING CAPACITY 2000 LB EACH

FIGURE 4–103. ANCHORING ARRANGEMENT, U-1 AIRCRAFT

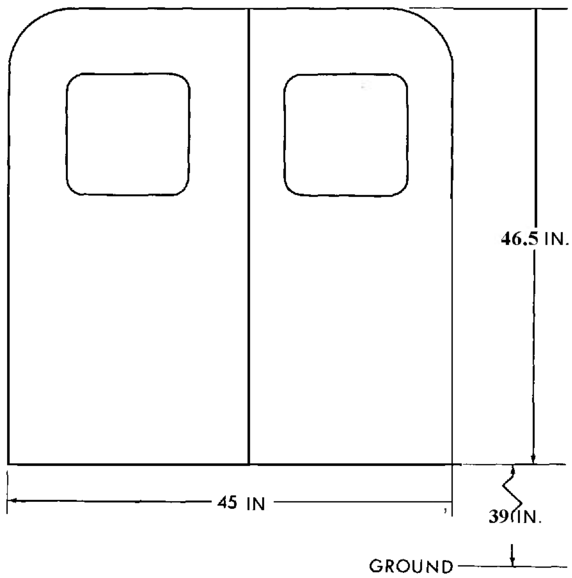


FIGURE 4–104. CARGO DOOR DIMENSIONS, U-1 AIRCRAFT

and **294.0** in the baggage compartment, as shown in Fig. 4—103. The upper cover of the aerial cargo hatch forms part of the baggage compartment floor and the lower cover is attached to the undersurface of the fuselage.

4-88.3 **PASSENGER DOOR.** The passenger door, located on the right side of the fuselage, is used primarily for loading and unloading of personnel, but may be used to load small items of cargo. On aircraft serial No. 59-2009 and subsequent, the passenger door is jettisonable.

4-89 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the U-1 aircraft:

Forward	9
Aft	2
Side	1.5
Vertical	2

4—90 CARGO LOADING AND UNLOADING PROVISIONS

An access ladder is provided to assist personnel in loading and unloading. The ladder can be attached to the lower door sill of the passenger doorway or the forward cargo doorway. Loading and unloading of general cargo is a manual operation.

TABLE 4–10. **MAXIMUM** CARGO DOORS PACKAGE SIZE, U-1 AIRCRAFT

	WIDTH (IN.)																
	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
LENGTH (IN.)	HEIGHT (IN.)																
45	45	45	45	45	45	45	45	45	44	44	44	44	43	42	41	40	36
50	45	45	45	45	45	45	45	45	44	44	44	44	43	42	41	40	36
55	45	45	45	45	45	45	45	45	44	44	44	44	43	42	41		
60	45	45	45	45	45	45	45	45	44	44	44	44	43				
65	45	45	45	45	45	45	45	45	44	44	44	44					
70	45	45	45	45	45	45	45	45	44	44							
75	45	45	45	45	45	45	45	45	44								
80	45	45	45	45	45	45	45	45									
85	45	45	45	45	45	45	45										
90	45	45	45	45	45	45	45										
95	45	45	45	45	45	45											
100	45	45	45	45	45												
105	45	45	45	45	45												
110	45	45	45	45													
115	45	45	45	45													
120	45	45	45														
125	45	45	45														
130	45	45	45														
135	45	45															
140	45	45															

SECTION XIX

U-6A

4—91 GENERAL DESCRIPTION

The **U-6A** is a single-engine, high-wing monoplane (Fig. **4—105).** It is designedto carry a pilot and five passengers. The **U-6A** is a utility aircraft, with a fixed conventional landing gear. The aircraft is used for personnel, cargo, and medical evacuation. Two litter patients and three passengers can be transported by this aircraft. It can also be used for parachute operations with a maximum of four parachutists. External load capability is **1000** pounds suspended on four bomb shackles, two under each wing with a capacity of **250** pounds per bomb shackle.

4—92 CARGO COMPARTMENT

The cargo compartment dimensions to the rear of the flight compartment seats are approximately **92** inches long, **48** inches wide, and **51** inches high. The width of **48** inches is nominal. **A** taper toward the rear reduces the width to approximately **42** inches (Fig. **4—106).** With the copilot's seat removed, the floor area available for payload is approximately **26** square feet.' **A** stowage compartment aft of the aft bulkhead has a capacity of approximately **41/2** cubic feet. Height of the cargo compartment floor above ground level is **46** inches.

4—92.1 FLOOR LOADING. The cargo compartment flooring consists of bakelite-type panels reinforced with metal and secured to the fuselage structure. The floor is designed to withstand a distributed load of 100 pounds per square foot.

4—92.2 ANCHORING ARRANGEMENT. The cargo compartment is provided with **5** removable tiedown rings, **4** nonremovable tiedown

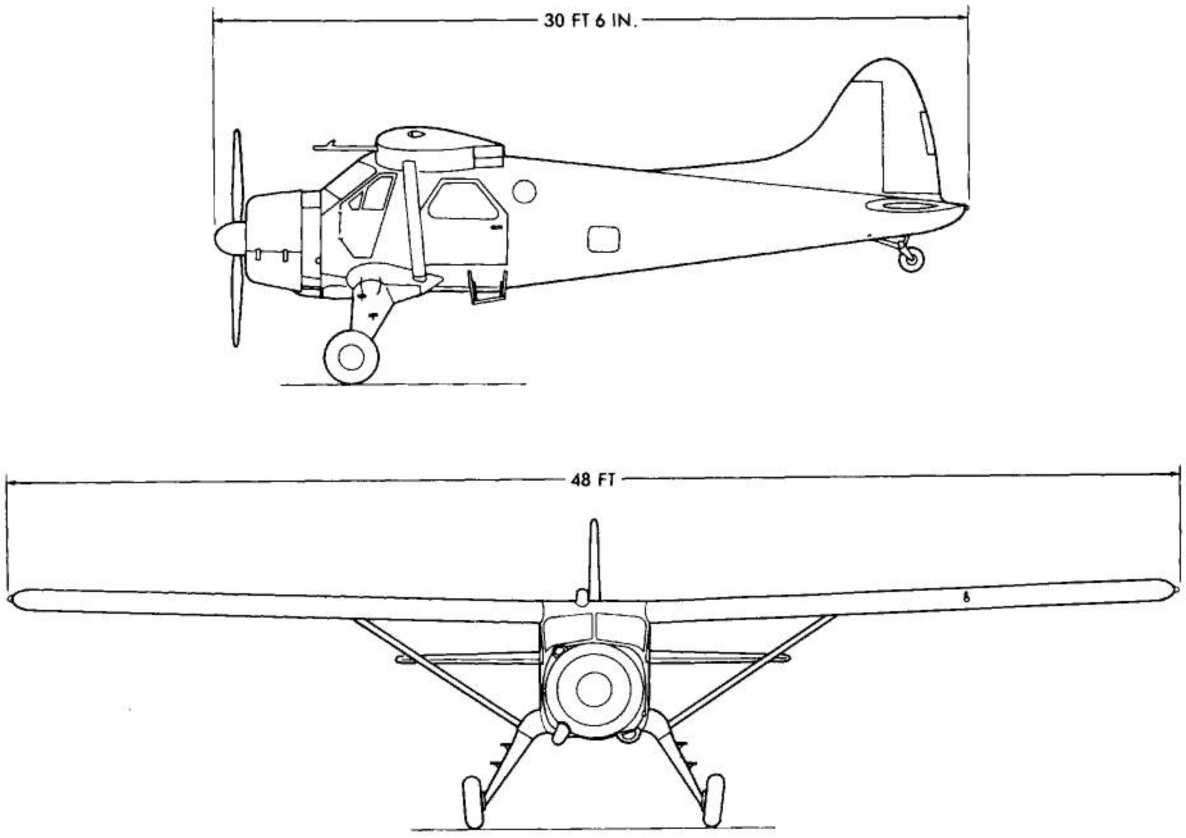
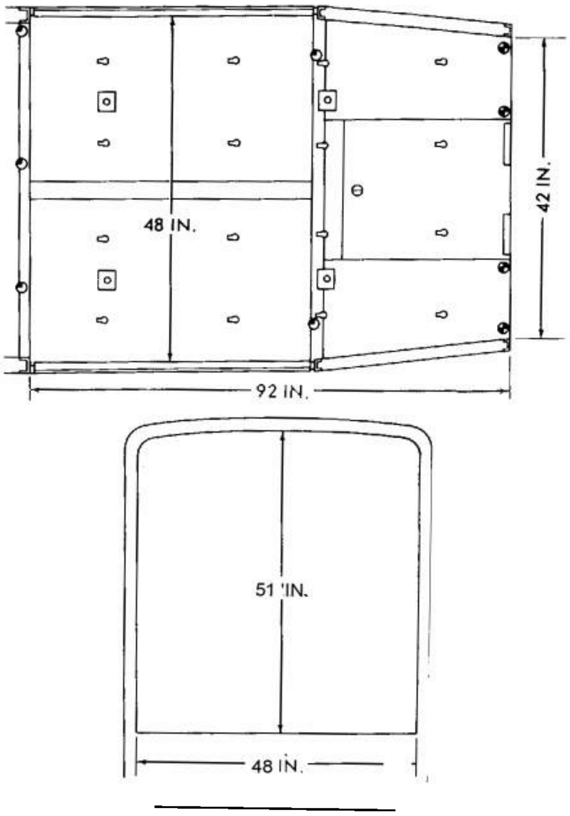


FIGURE 4—105. U-6A AIRCRAFT



SEAT LOCKING PLATES (4)
SEAT PICKUP SLOTS (16)
REMOVABLE TIEDOWN RINGS (1800-LB RATING) (5)
NONREMOVABLE TIEDOWN RINGS (1800-LB RATING) (4)
FLOOR HATCH LOCK RELEASE (1)

FIGURE 4–706. CARGO COMPARTMENT DIMENSIONS AND ANCHORING ARRANGEMENT. U-6A AIRCRAFT

rings, 4 seat locating plates, 16 seat pick-up slots, and 1 floor hatch lock release. The tiedown rings have a load strength of 1800 pounds. Location and ratings are shown in Fig. 4–106.

4–93 CARGO DOORS

Cargo doors are provided on each side of the cabin and can be easily removed to facilitate loading. The doors provide an opening 30 inches wide by 40 inches high.

4–94 RESTRAINT CRITERIA

The following restraint factors in g's axe applicable to the U-6A aircraft:

Forward	8.0
Aft	1.5
Side	1.5
Vertical	2.25

4–95 CARGO LOADING AND UNLOADING PROVISIONS

Special aids for loading and unloading are not provided. Cargo must be loaded into the aircraft manually.

SECTION XX

UH-1

4—96 GENERAL DESCRIPTION

The UH-1 is a turbine-powered utility helicopter, featuring a skid-type landing gear (Fig. 4—107). There are three models of the UH-1—the UH-1A, B, and D. The UH-1A and B are used primarily for utility purposes, such as aerial fire support, medical evacuation, and aerial command posts; the UH-1D is used as a light tactical transport. The primary difference between the various models is the cargo compartment size. External cargo can be carried by means of a short, single-cable suspension unit secured to the primary structure and located at the approximate center of gravity. Maximum sling load capacity of the UH-1A is 3000 pounds; the UH-1B, 3500 pounds; and the UH-1D, 4000 pounds. The maximum internal cargo load (with maximum fuel) for the UH-1A is 1843 pounds; the UH-1B, 2857 pounds; and the UH-1D, 2305 pounds.

4—97 CARGO COMPARTMENT

The cargo compartment provides a volume of approximately 140 cubic feet (A and B models) or 220 cubic feet (D model) for cargo and/or personnel loading. On all models, additional space may be made available by removal of the copilot's seat. Total weight in this area, however, cannot exceed 230 pounds and must be secured to adjacent cargo, since tiedown fittings are not provided in this area. Cargo compartment dimensions for the various models are shown in Figs. 4—108, 4—109, and 4—110.

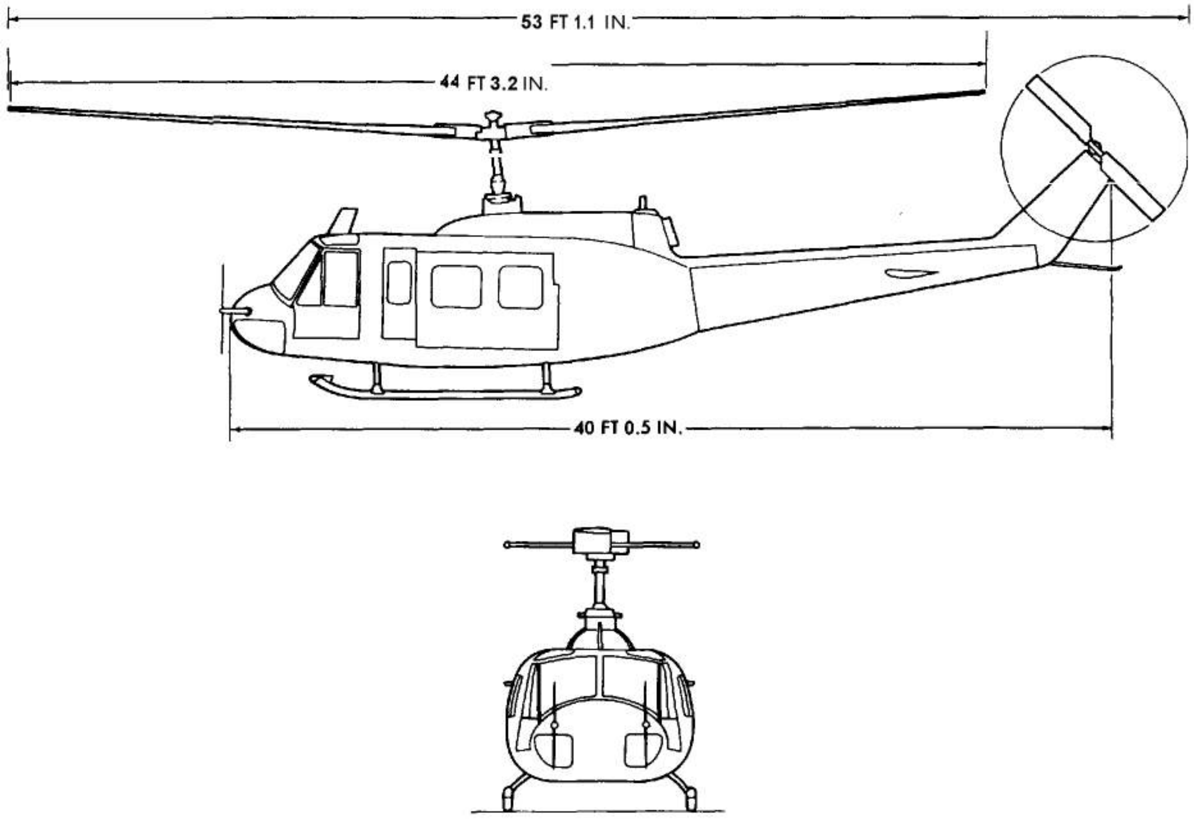


FIGURE 4—107. UH-I HELICOPTER (D MODEL *SHOWN)*

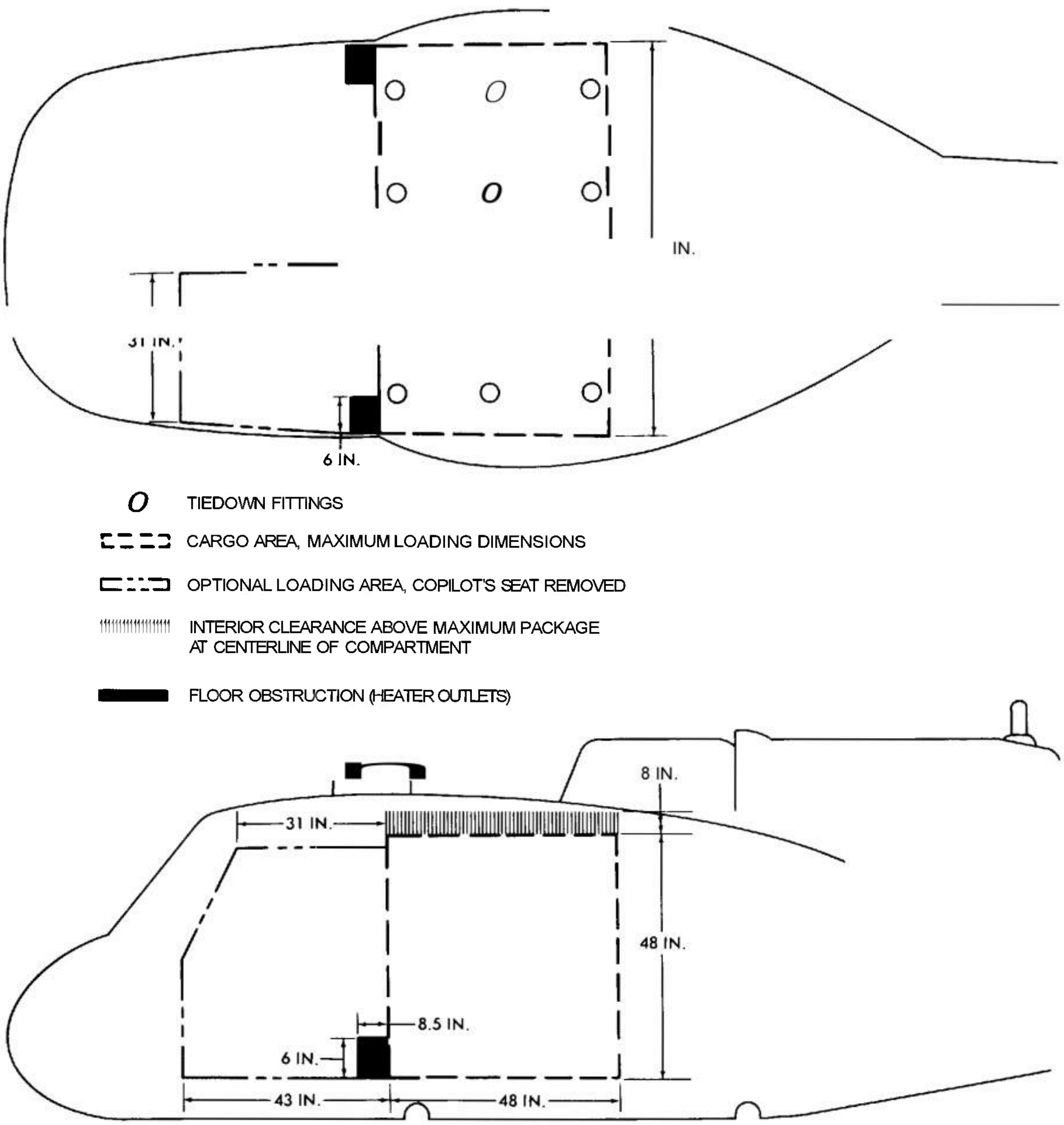


FIGURE 4-108. CARGO COMPARTMENT DIMENSIONS AND ANCHORING ARRANGEMENT. UH-1A HELICOPTER

4—97.1 FLOOR LOADING. The cargo compartment floor is designed to withstand a distributed load of 175 pounds per square foot. The aft cargo area (baggage compartment) on the UH-1B is designed to withstand a distributed load of 150 pounds per square foot and a maximum weight of 200 pounds.

4—97.2 ANCHORING ARRANGEMENT. Tiedown fittings (12 for the A model, 27 for the B model, and 39 for the D model) are located on the cargo compartment floor as shown in Figs. 4—108, 4—109, and 4—110. The tiedown fittings have a rated strength of 1250 pounds in a vertical direction and 500 pounds in a horizontal direction. Six stan-

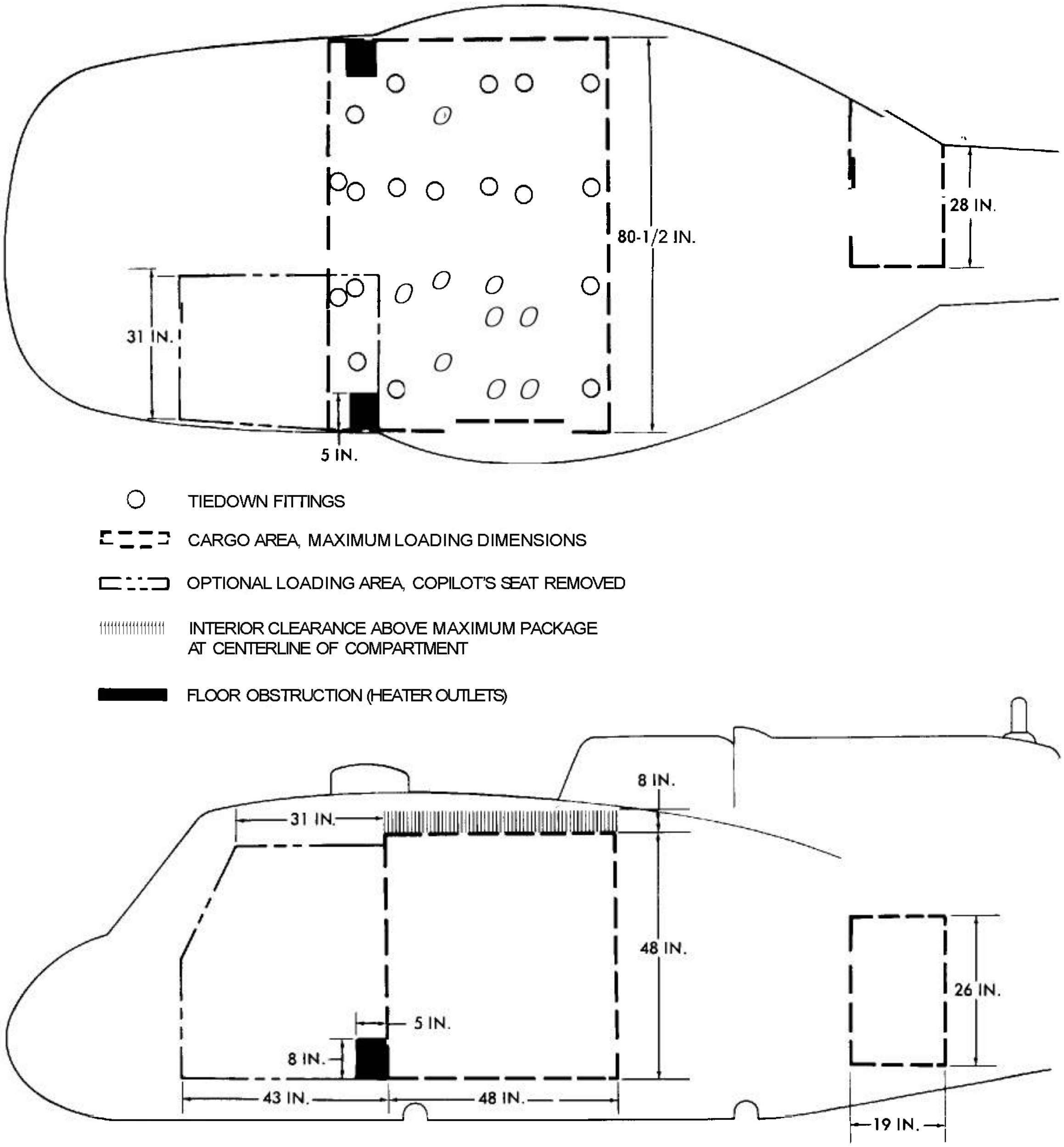


FIGURE 4–109. CARGO COMPARTMENT DIMENSIONS AND ANCHORING ARRANGEMENT, UH-1B HELICOPTER

chion fittings are provided on the UH-1D for installing troop seats or litters.

4–98 CARGO DOORS

Two cargo doors, one on each side, slide aft exposing the entire cargo compartment area, thereby providing an unrestricted loading space for cargo or equipment transportation.

4–99 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the UH-1 helicopter:

Forward	4.0
Aft	2.0
Side	1.5
Vertical	2.0

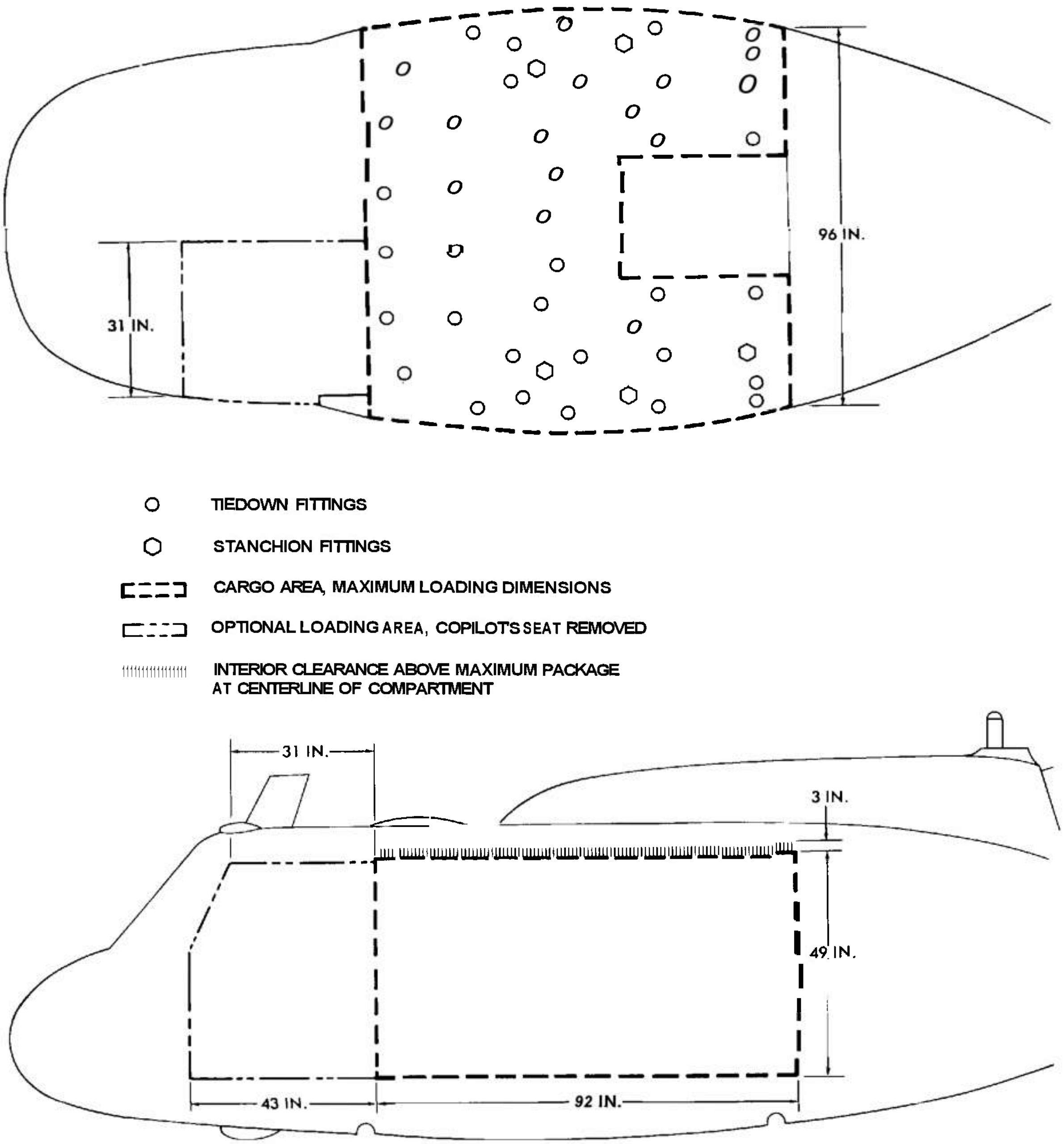


FIGURE 4-170. CARGO COMPARTMENT DIMENSIONS AND ANCHORING ARRANCEMENT, UH-ID HELICOPTER

4-100 CARGO LOADING AND UNLOADING PROVISIONS

The helicopter requires no special loading preparation. The loading procedure consists only of placing the heaviest items to be loaded as far aft as possible. Such placement locates the cargo nearer to the helicopter center of gravity, allowing a maximum cargo load to be transported.

SECTION XXI

CH-21

4—101 GENERAL DESCRIPTION

The CH-21 is a single-engine, all-metal, tandem-rotor, cargo helicopter (Fig. 4—111). It has dual controls and features a fixed tricycle landing gear. Two models of the CH-21 helicopter are in Army inventory, the B and C models, both having essentially the same performance characteristics. The CH-21 is designed to transport troops and cargo. The helicopter is equipped with a 5000-pound capacity, external cargo sling for external transport of cargo.

4—102 CARGO COMPARTMENT

The cargo compartment is basically a rectangular-shaped space. It is 240 inches long, 66 inches high, 46 inches wide at floor level, and 68 inches wide at midpoint between the floor and overhead. The cargo floor is 38 inches above the ground at the main entrance door. Heat ducts, which also enclose the drive shaft, extend the full length of the cargo compartment. Dimensions and contours of the cargo compartment are shown in Fig. 4—112.

4—102.1 FLOOR LOADING. The cargo compartment flooring consists of 11 hinged metal panels secured to the fuselage structure with screws, permitting easy removal and replacement. The flooring is reinforced with skid rails for ease of cargo handling. The flooring is designed to withstand evenly distributed loads up to a maximum of 130 pounds per square foot. A maximum concentrated load of 340 pounds per square foot is permissible, provided a maximum of 500 pounds per running foot is not exceeded. Maximum capacity of each cargo compartment is shown in Fig. 4—113. Internal cargo is limited to items of relatively small size and low density due to the dimensions of the cargo.compartment doors. and floor loading limitations. The transport of vehicles and large or high-density cargo is accomplished by suspension of the load from the 5000-pound capacity, external cargo sling.

4—102.2 ANCHORING ARRANGEMENT. There are twenty-five 2000-pound capacity tie-down fittings installed on the cargo floor. In addition to the floor fittings, twenty

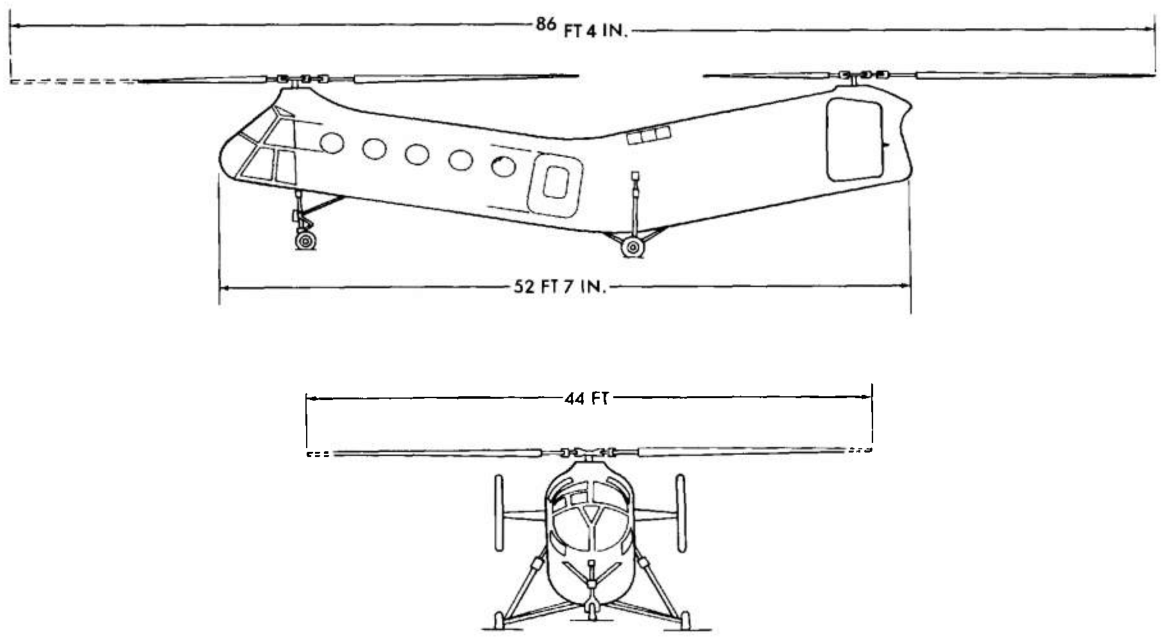


FIGURE 4—111. CH-21 HELICOPTER

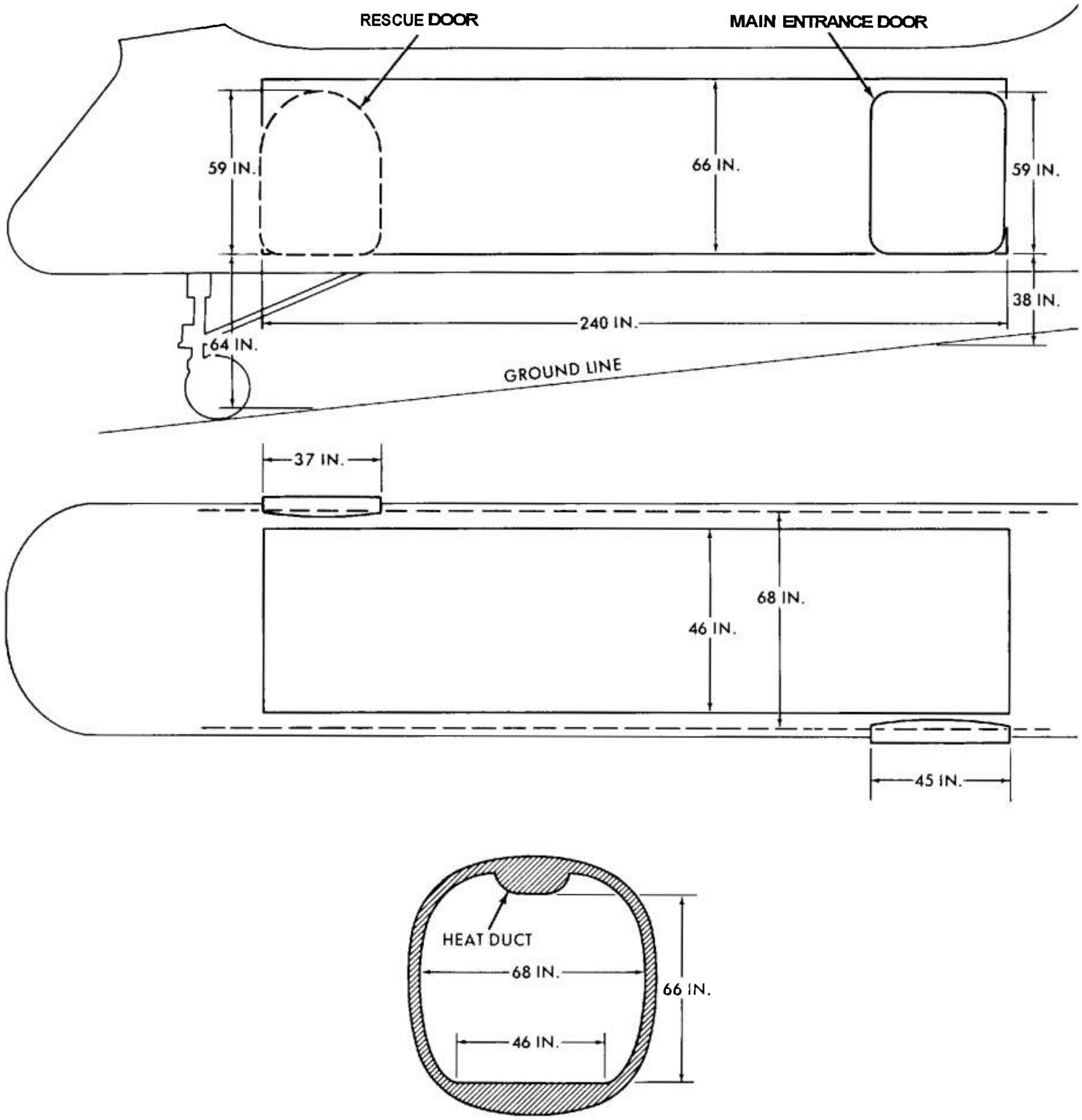


FIGURE 4-112. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, CH-21 HELICOPTER

2000-pound capacity and two 5000-pound capacity tiedown fittings are bolted to the fuselage above the floor. Locations and ratings of the tiedown fittings are shown in Fig. 4-113.

4-103 CARGO DOORS

The cargo compartment is accessible through two doors, the main entrance door and the rescue door (Fig. 4-112). Both are sliding doors mounted on tracks. The main entrance door is rectangular in shape and is located on the left side of the fuselage near the aft end of the cargo compartment. It is 38 inches above the ground, 59 inches high, and 45 inches wide. The rescue door is square-shaped at the bottom and oval-shaped at the top. It is located on the right side of the fuselage at the forward end of the cargo compartment. The rescue door

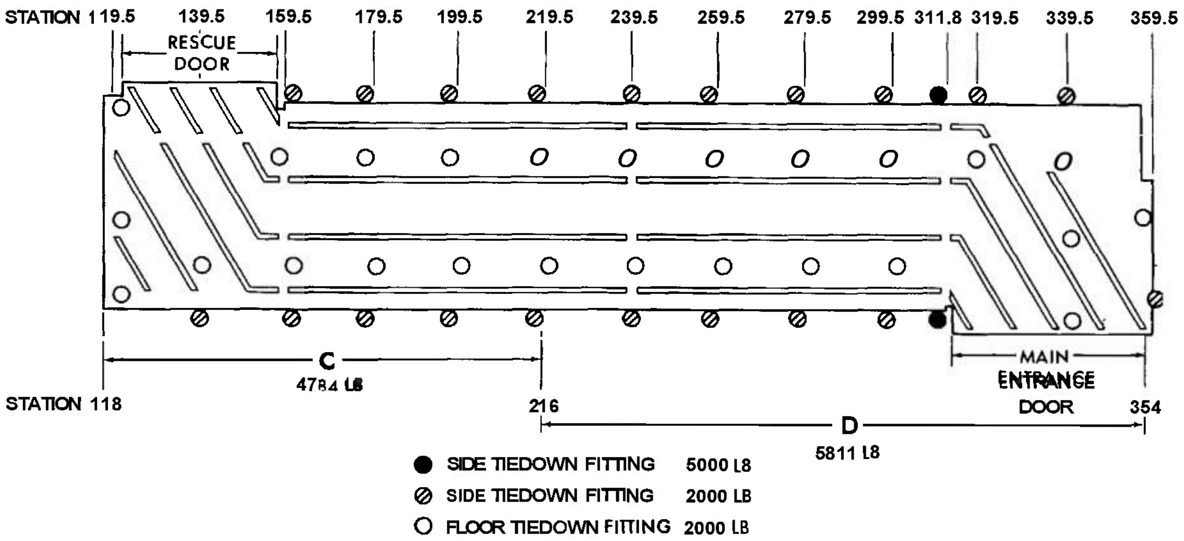


FIGURE 4-113. CARGO COMPARTMENT WEIGHT LIMITS AND ANCHORING ARRANGEMENT, CH-21 HELICOPTER

is 64 inches above the ground, 59 inches high, and 37 inches wide. The maximum widths for various heights and lengths of cargo which can be loaded through the doors are shown in Fig. 4-114. For example, given a crate 49 inches long by 53 inches high, the maximum permissible width for loading through the main entrance door is 38 inches.

4-104 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the CH-21 helicopter:

Forward	8.0
Aft	2.0
Side	1.5
Vertical	2.0

4-105 CARGO LOADING AND UNLOADING PROVISIONS

A hydraulically operated rescue hoist and boom, located forward and above the rescue door, is used for raising and lowering personnel and cargo while the helicopter is hovering.

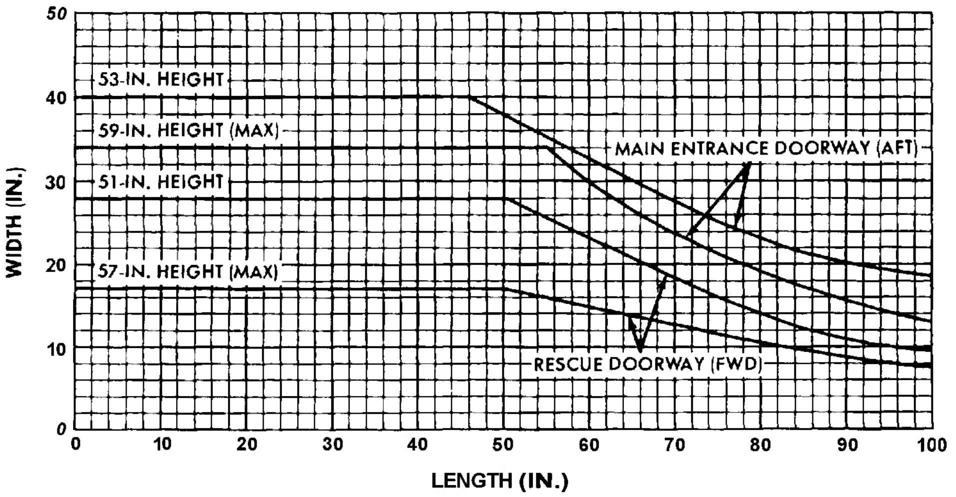


FIGURE 4-114. MAIN ENTRANCE DOOR AND RESCUE DOOR PACKAGE SIZE GRAPH, CH-21 HELICOPTER

SECTION XXII

CH-34

4–106 GENERAL DESCRIPTION

The CH-34 is an all-metal, single-engine helicopter with a four-blade main rotor (Fig. 4–115). There are two models of this helicopter, the A and C. Both models are identical except for installation of automatic stabilization equipment in the C model. The helicopter is designed for internal transport of troops and cargo. A 5000-pound capacity external sling is provided for transporting external sling loads.

4–107 CARGO COMPARTMENT

The cargo compartment extends from station 82.5 to station 246. The compartment is a rectangular space 163.5 inches long and 59 inches wide at floor level. Forward of station 112, the compartment height is limited to 49 inches; aft of station 112, the height is 70 inches. Height of the cargo compartment floor above ground level is 34 inches. Dimensions and contours of the cargo compartment are shown in Fig. 4–116.

4–107.1 FLOOR LOADING. The cargo compartment flooring is constructed of aluminum sheets with honeycomb cores of aluminum foil between the sheets. Skid strips are installed to facilitate handling of heavy cargo. The flooring is designed to withstand an evenly distributed load of 200 pounds per square foot. Concentrated loads exceeding design strength weight limits can be loaded by using shoring. The total cargo load, including external sling loads, must not exceed 5000 pounds. All internal cargo should be distributed evenly fore and *aft* of station 154, the loading data line.

4–107.2 ANCHORING ARRANGEMENT. Thirty-five combination tiedown and troop seat fittings are installed on the cargo floor. The

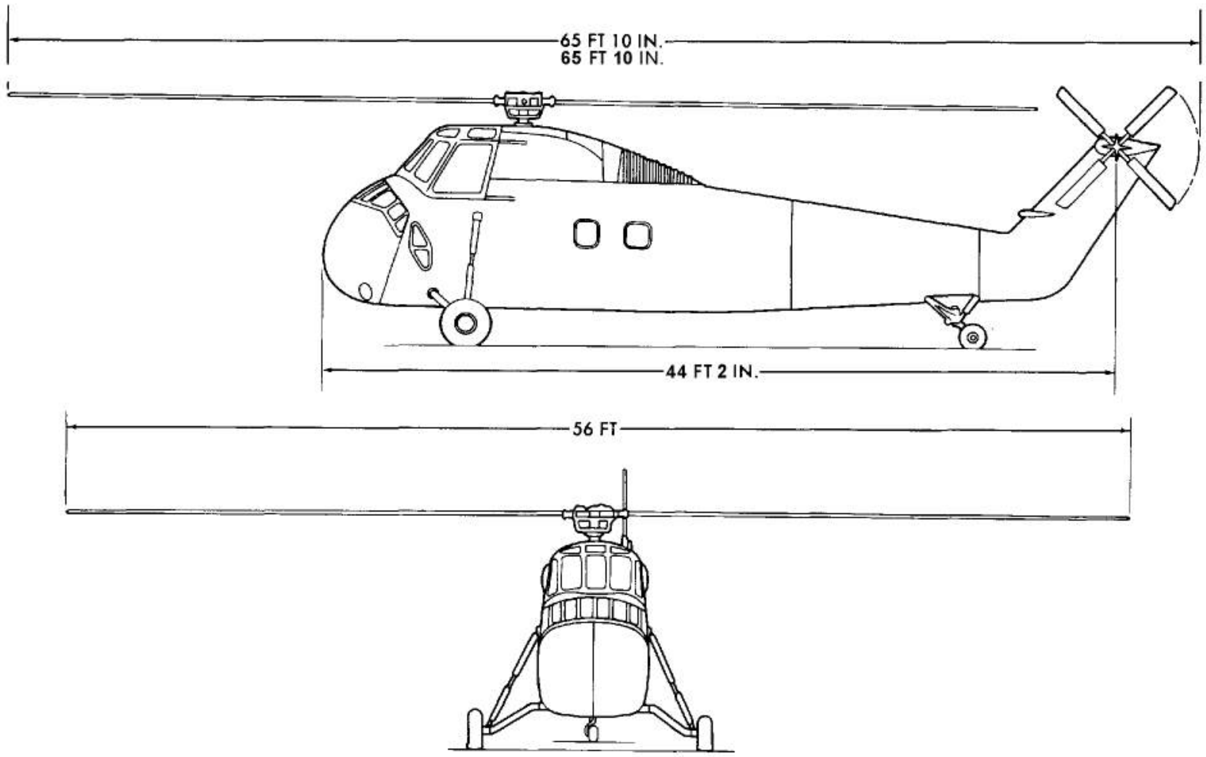


FIGURE 4–115. CH-34 HELICOPTER

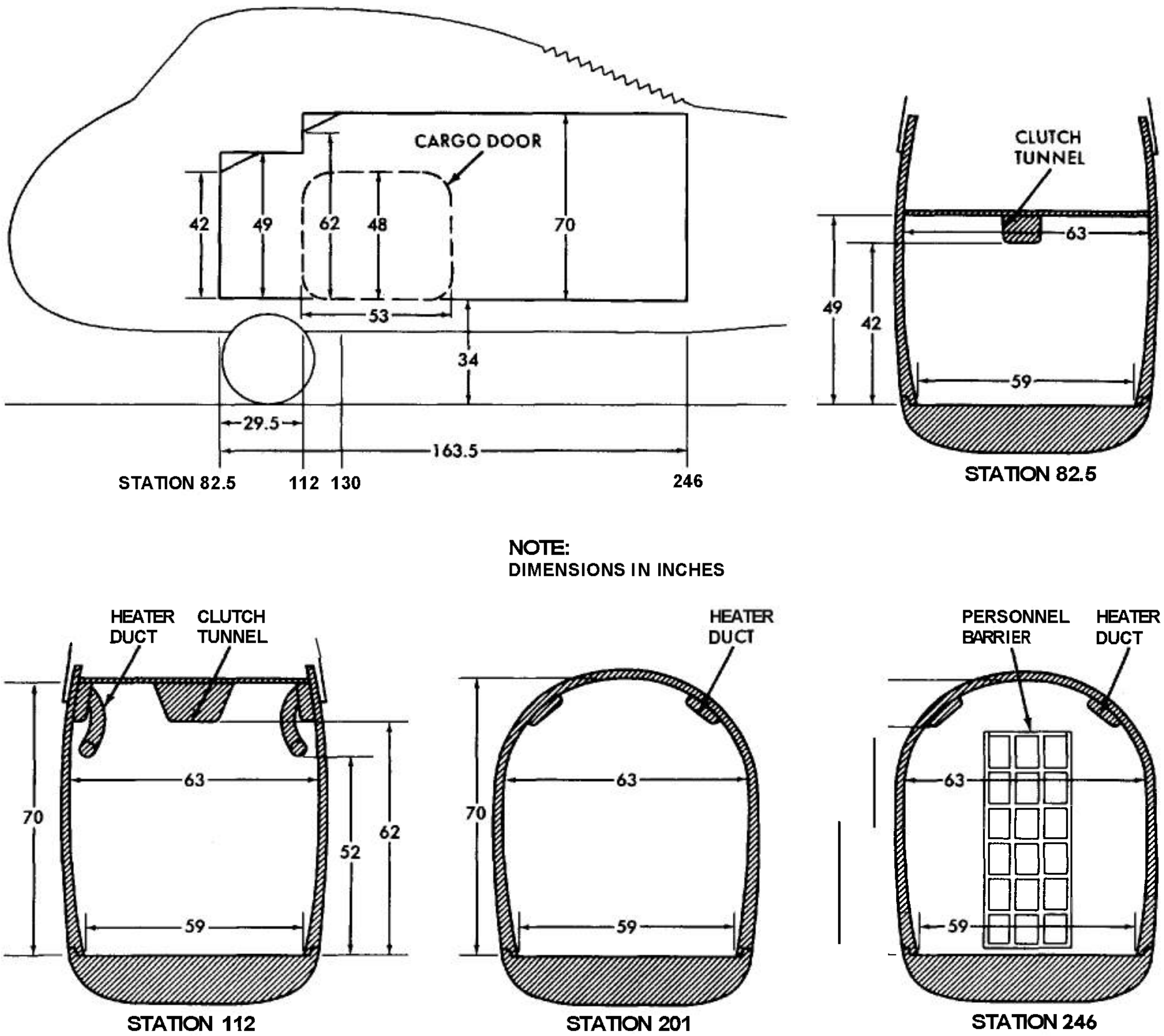


FIGURE 4–116. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, *CH-34* HELICOPTER

ring in each fitting is capable of restraining a 1250-pound load in any direction. Locations of the fittings are shown in Fig. 4—117.

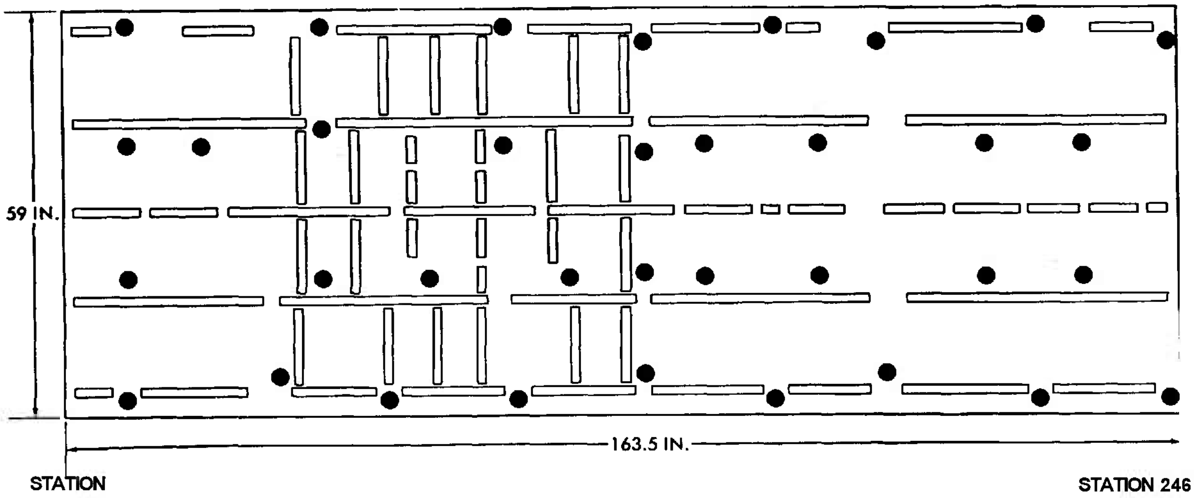
4—108 CARGO DOOR

The side cargo door, located between stations 112 and 165 on the right side of the helicopter, is of the sliding type and may be jettisoned for emergency escape. The side cargo door is 53 inches wide by **48** inches high. The maximum cargo package size that can be loaded through the opening can be determined from Table 4—41 as follows:

a. In the length column find the longest dimension of the package. If the exact dimension is not shown, use the next larger dimension.

b. In the width column find the shortest dimension of the package. If the exact dimension is not shown, use the next larger dimension.

c. At the intersection of the length and width dimensions in the body of the table, find the maximum height. If the height of the package is the same or less than this dimension, the package can be loaded.



NOTE:
ALL TIEDOWN FITTINGS ARE RATED AT 1250 LB.

FIGURE 4–117. ANCHORING ARRANGEMENT, CH-34 HELICOPTER

TABLE 4–11. MAXIMUM SIDE CARGO DOOR PACKAGE SIZE, CH-34 HELICOPTER

	WIDTH (IN.)									
LENGTH (IN.)	5	10	15	20	25	30	35	40	45	48
55	42	42	42	42	42	42	42	40	40	38
60	42	42	42	42	42	42	42	40	38	
65	42	42	42	42	42	42	40	38		
70	42	42	42	42	42	42	40			
75	42	42	42	42	42	40	38			
80	42	42	42	42	42	40				
85	42	42	42	42	40	40				
90	42	42	42	42	40	38				
95	42	42	42	40	40					
100	42	42	42	40	40					
105	40	40	40	40	38					
110	40	40	40	40	38					
115	40	40	40	40						
120	40	40	40	38						
125	38	38	38	38						
130	38	38	38							
135	38									

4–109 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the CH-34 helicopter:

Forward	4.0
Aft	2.0
Side	1.5
Vertical	1.0

4–110 CARGO LOADING AND UNLOADING PROVISIONS

A 600-pound capacity, hydraulic rescue hoist, with approximately 95 feet of cable, is mounted on a fixed stand above and outside the cargo door. It is used for raising and lowering personnel and cargo while the helicopter is hovering.

SECTION XXIII

CH-37B

4—111 GENERAL DESCRIPTION

The **CH-37B** is an all-metal, twin-engine helicopter with a single five-blade main rotor and a single four-blade antitorque tail rotor (Fig. 4—118). It is a medium transport helicopter with a principal mission of transporting troops and cargo. It can also be used for medical evacuations and parachute operations. Jettisonable fuel tanks may be mounted externally to increase the range. It is capable of transporting **23** combat-equipped troops, **23** parachutists, or 24 litter patients. A 10,000-pound capacity external cargo sling is attached to the four corners of the floor hatchway for transporting external sling loads.

4—112 CARGO COMPARTMENT

The cargo compartment extends from station 80 to station 444. The forward 80 inches of the cargo compartment floor, from station 80 to station 160, form the floor of the ramp which can be lowered and raised to facilitate cargo loading and unloading. The only obstructions in the cargo compartment are the removable auxiliary power unit which is located on the aft corner of the floor, the pilot's compartment ladder in the center forward section, the cargo monorail, and the heater duct along the ceiling. The pilot's compartment ladder may be folded upward. Dimensions of the cargo compartment are shown in Figs. 4—119 and 4—120.

4—112.1 FLOOR LOADING. The flooring, extending the entire length of the cargo compartment, is made of aluminum panels reinforced with stringers and completely covered with nonskid material for personnel footing. Magnesium skid strips are installed

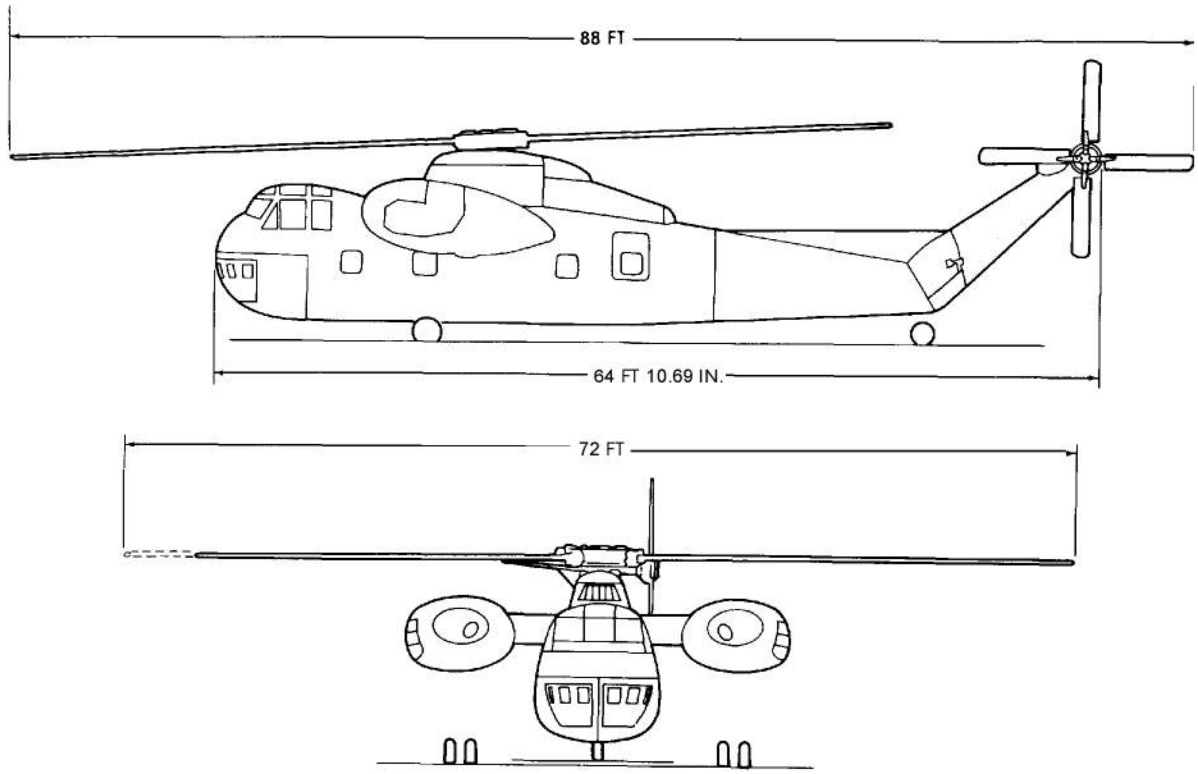


FIGURE 4—118. CH-37B HELICOPTER

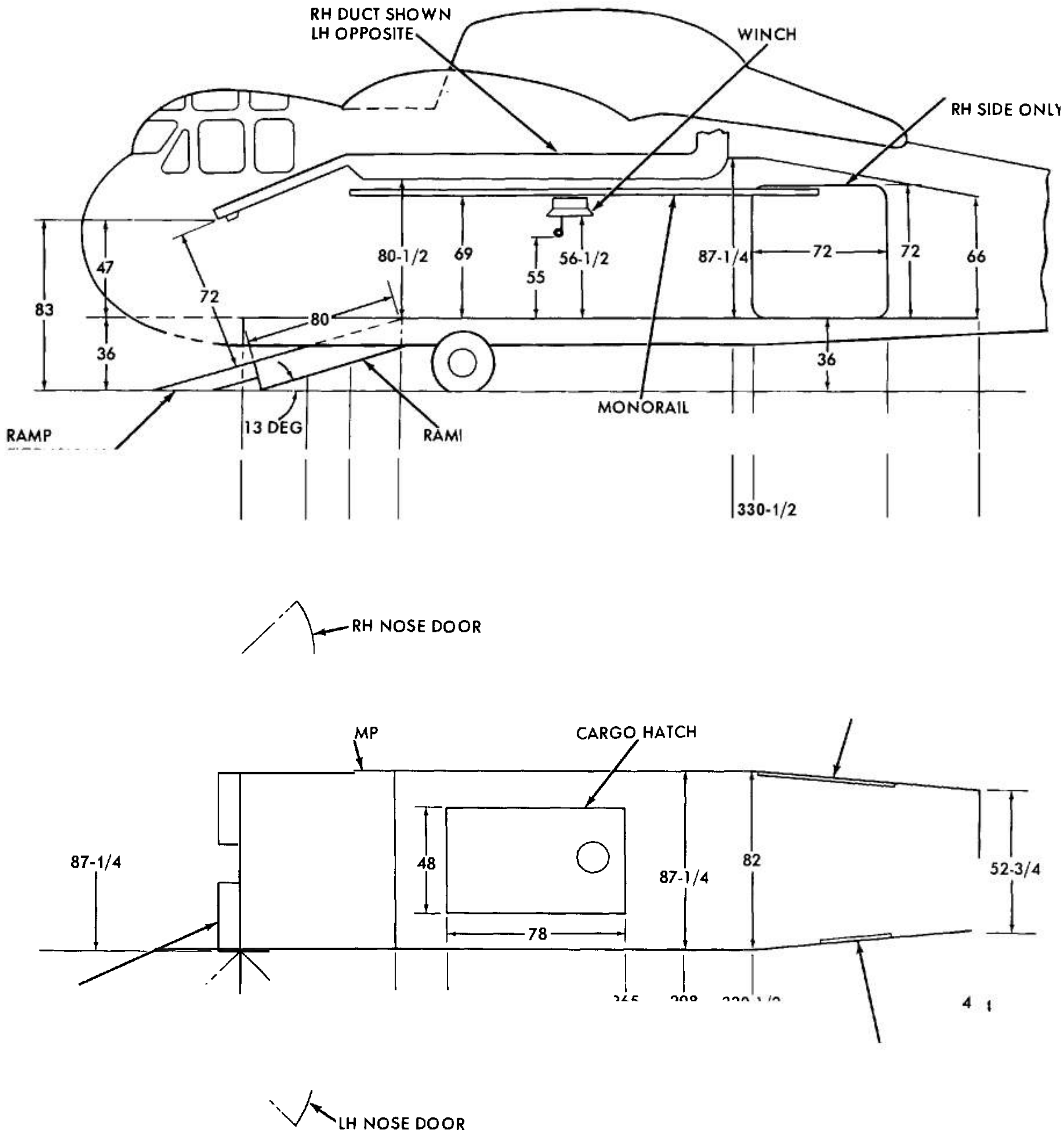


FIGURE 4–119. CARGO COMPARTMENT DIMENSIONS. CH-37B HELICOPTER

to facilitate movement of cargo. Except for the treadways, the flooring is designed to withstand a maximum distributed load of 300 pounds per square foot. The treadways will withstand loads as shown in Fig. 4—121. Shoring may be utilized to span the areas or bridge distances between vehicle tire widths and treadway widths if the vehicle tire width should exceed the treadway width. Maximum capacities of each cargo compartment are shown in Fig. 4—122.

4—112.2 ANCHORING ARRANGEMENT. A total of 112 tiedown fittings is installed on the floor and ramp as shown in Fig. 4—123.

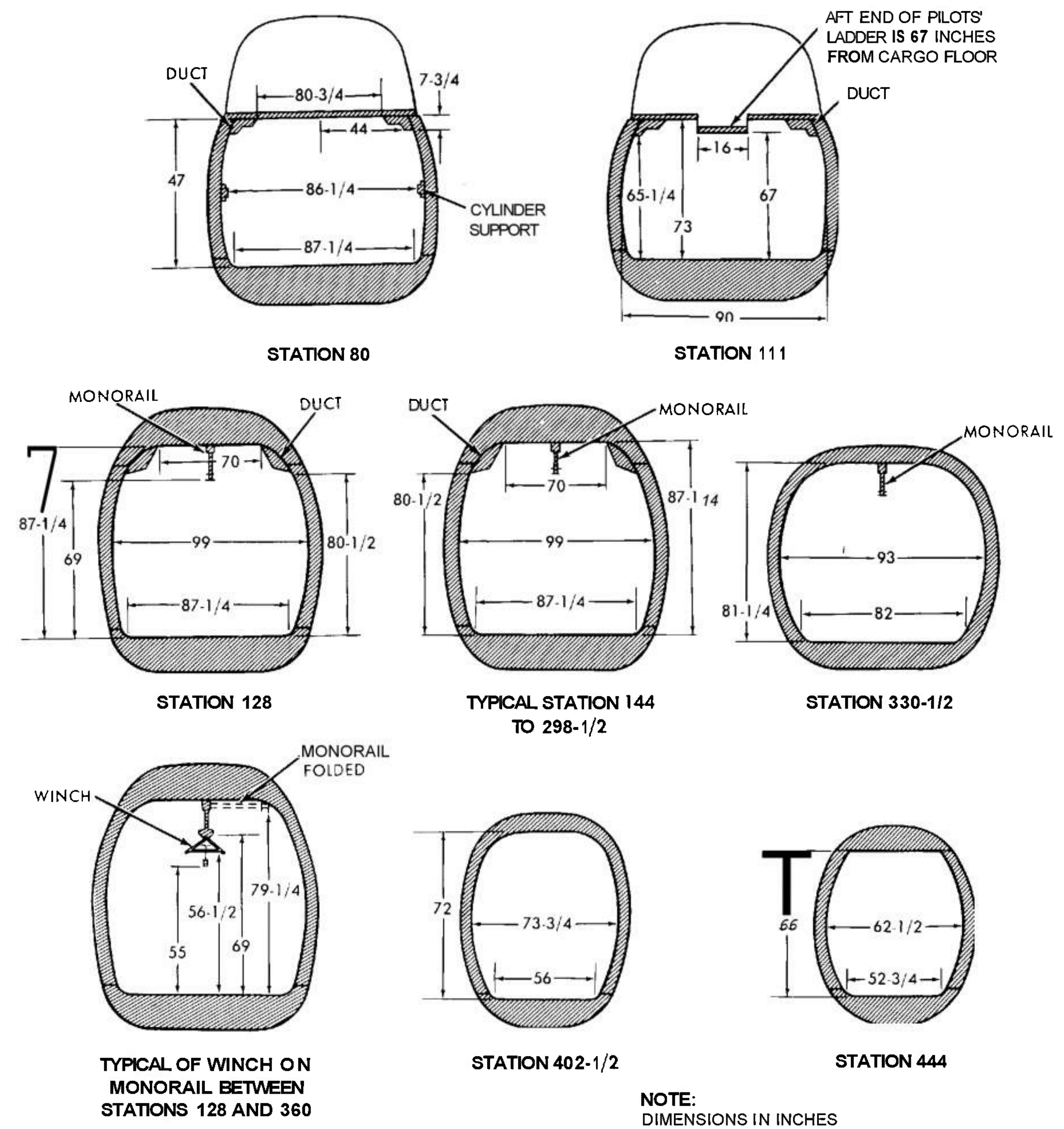


FIGURE 4–120. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, CH-37B HELICOPTER

Eighteen are rated at 5000 pounds; 94 are rated at 2200 pounds, of which **44** incorporate studs for installation of troop seats.

4–113 CARGO DOORS AND RAMPS

4–113.1 CARGO DOORS. The cargo doors consist of the clamshell nose doors, a sliding cargo and passenger door on the aft right-hand side of the fuselage, and a cargo hatch (Fig. 4–119).

4–113.1.1 Nose Doors. The clamshell nose doors form the nose of the fuselage and open outward to permit loading through the forward part of the cargo compartment.

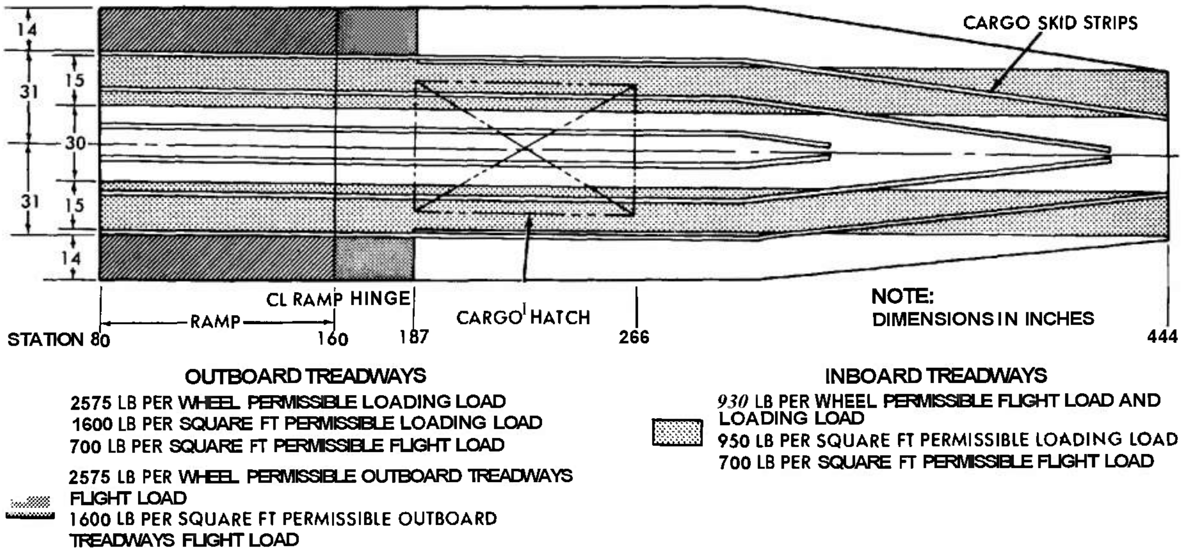


FIGURE 4-121. TREADWAY CAPACITIES, CH-378 HELICOPTER

The size opening provided by the nose doors is 72 inches high by 87-1/4 inches wide. Typical maximum cargo package sizes that may be loaded through the opening are listed below. Slightly larger packages may be loaded by successively tipping the rear end of the cargo and shoving it aft a little at a time.

Length (In.)	Width (In.)	Height (In.)
360	46	44
264	72	51
201	72	56
108	85	63
73	85	65

4-113.1.2 Cargo Door. The sliding cargo door (Fig. 4-119) is located between stations 330 and 402 on the right-hand side of the fuselage. It is 72 inches square and rides on tracks secured to the fuselage above and below the door. It provides an opening of approximately 70 to 71 inches. Maximum cargo package sizes that can be angled through this door and slid forward into the compartment can be determined from Table 4-12 as follows:

a. In the length column find the longest dimension of the package. If the exacf dimension is not shown, use the next larger dimension.

b. In the width column find the shortest dimension of the package. If the exact dimension is not shown, use the next larger dimension.

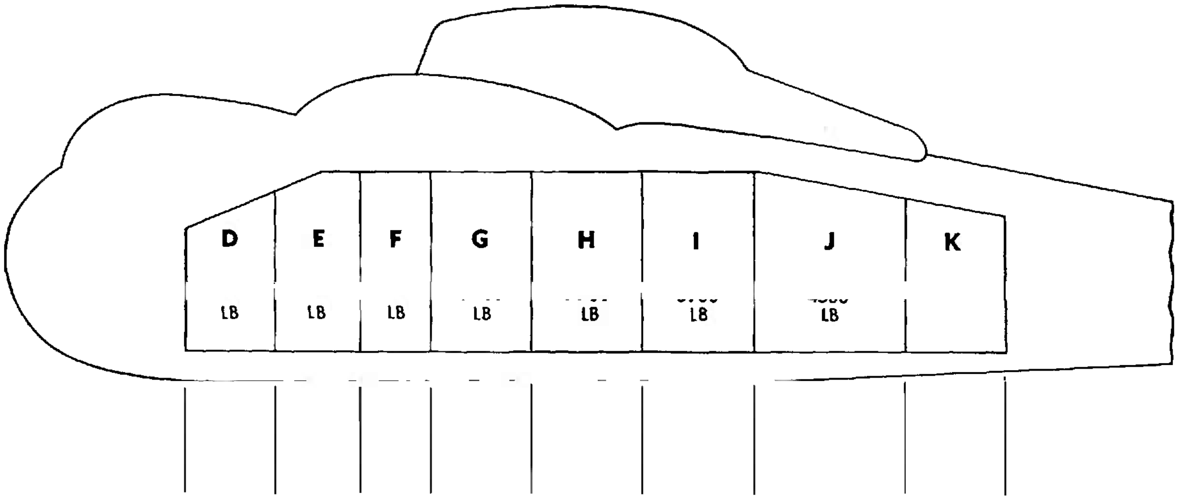
c. At the intersection of the length and width dimensions in the body of the table, find the maximum height. If the height of the package is the same or less than this dimension, the package can be loaded.

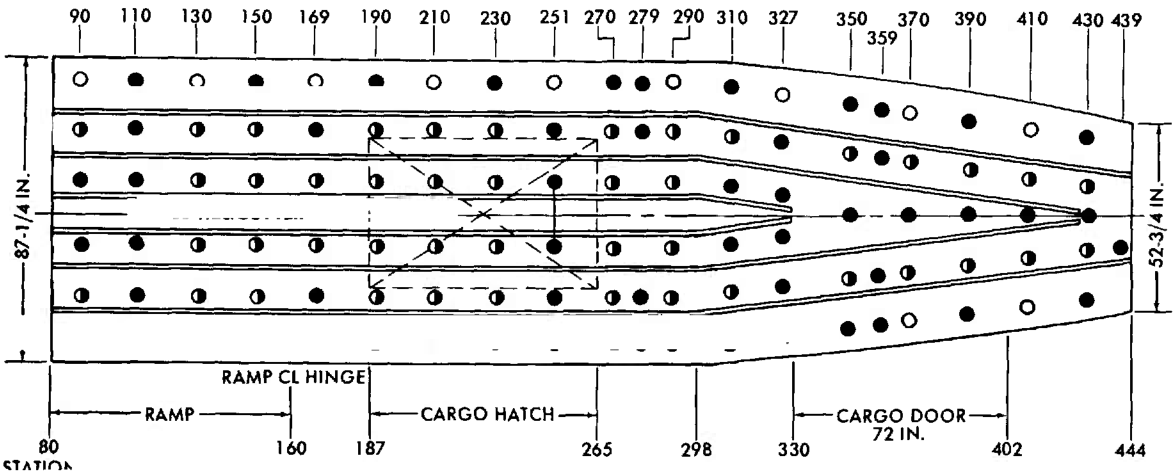
4-113.1.3 Cargo Hatch. A 78- by 48-inch hatch is located in the center of the cargo compartment for inflight cargo loading or rescue operations. The section of the hatch cover which overlaps into the treadway is reinforced and is capable of withstanding the same loads as the treadway. The rest of the hatch cover is limited to 300 pounds per square foot. The maximum package height that can be loaded through the hatch is 55 inches.

4-113.2 RAMPS. The cargo ramp is the forward 80 inches of the cargo floor (Fig. 4-119). When lowered, it presents a slope of approximately 13 degrees to the ground. For truck-bed loading, it can be placed in the horizontal position. The maximum

TABLE 4-12. **MAXIMUM** SIDE CARGO DOOR PACKAGE SIZE, CH-37B HELICOPTER

	WIDTH (IN.)											
LENGTH (IN.)	10	15	20	25	30	35	40	45	50	55	60	65
60	70	70	70	70	70	70	70	70	70	70	67	67
70	70	70	70	70	70	70	70	70	70	70	65	63
80	70	70	70	70	70	70	70	70	70	60	55	
90	70	70	70	70	70	70	70	70	70	55		
100	70	70	70	70	70	70	70	68	67			
110	70	70	70	70	70	70	70	68	60			
120	70	70	70	70	70	70	70	68				
130	70	70	70	70	70	70	68					
140	70	70	70	70	70	70	68					
150	70	70	70	70	70	51						
160	70	70	70	70	70	51						
170	70	70	70	70	51							
180	70	70	70	70	51							
190	70	70	70	51								
200	70	70	70	51								
210	70	70	55	51								
220	70	70	55									
230	70	70	51									
240	70	70	51									
250	51	51	51									
260	51	51	51									
270	51	51										
280	51	51										
290	51	51										
300	51	51										
310	51	51										
320	51	51										





weight that can be placed on the ramp and still permit the ramp to be raised is *2000* pounds. **Two** removable ramp extensions may be hinged to the forward end of the ramp, permitting vehicles and skidded cargo to be moved up the ramp and into the cargo compartment.

4–114 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the CH-37B helicopter:

Forward	4.0
Aft	2.0
Side	1.5
Vertical	2.0

4–115 CARGO LOADING AND UNLOADING PROVISIONS

Cargo loading and unloading provisions consist of a traverse hoist system, consisting of a monorail and an electrically driven 2000-pound capacity winch. Cargo can be loaded with the hoist system through the right side cargo door and the clamshell nose doors. The hoist system can **also** be used to load cargo, while hovering, through the cargo hatch.

SECTION XXIV

CH-47A

4—116 GENERAL DESCRIPTION

The CH-47A is a twin-engine, tandem-rotor, medium-transport helicopter designed to accommodate troops and cargo (Fig. **4—124).** The helicopter is equipped with a nonretractable quadricycle landing gear and features a sealed hull for emergency water landing capability. It has a sling load capacity of **16,000** pounds **and** contains a power-operated rear loading ramp which permits straight-in loading.

4—117 CARGO COMPARTMENT

The cargo compartment is a uniform, rectangular-shaped area **366** inches long, 90 inches wide, and ***78*** inches high. The height of the compartment floor above ground is 30 inches. The cargo compartment has an internal load capacity of **16,000** pounds at helicopter maximum gross weight of 33,000 pounds. Cargo compartment dimensions are shown in Fig. **4—125.**

The cargo compartment flooring, from station **200** to **400 and** from butt line **44** left to 44 right, rests on rubber vibration insulators which reduce overall internal load vibrations.

A 117.1 FLOOR LOADING. The cargo compartment distributed weight limits are shown

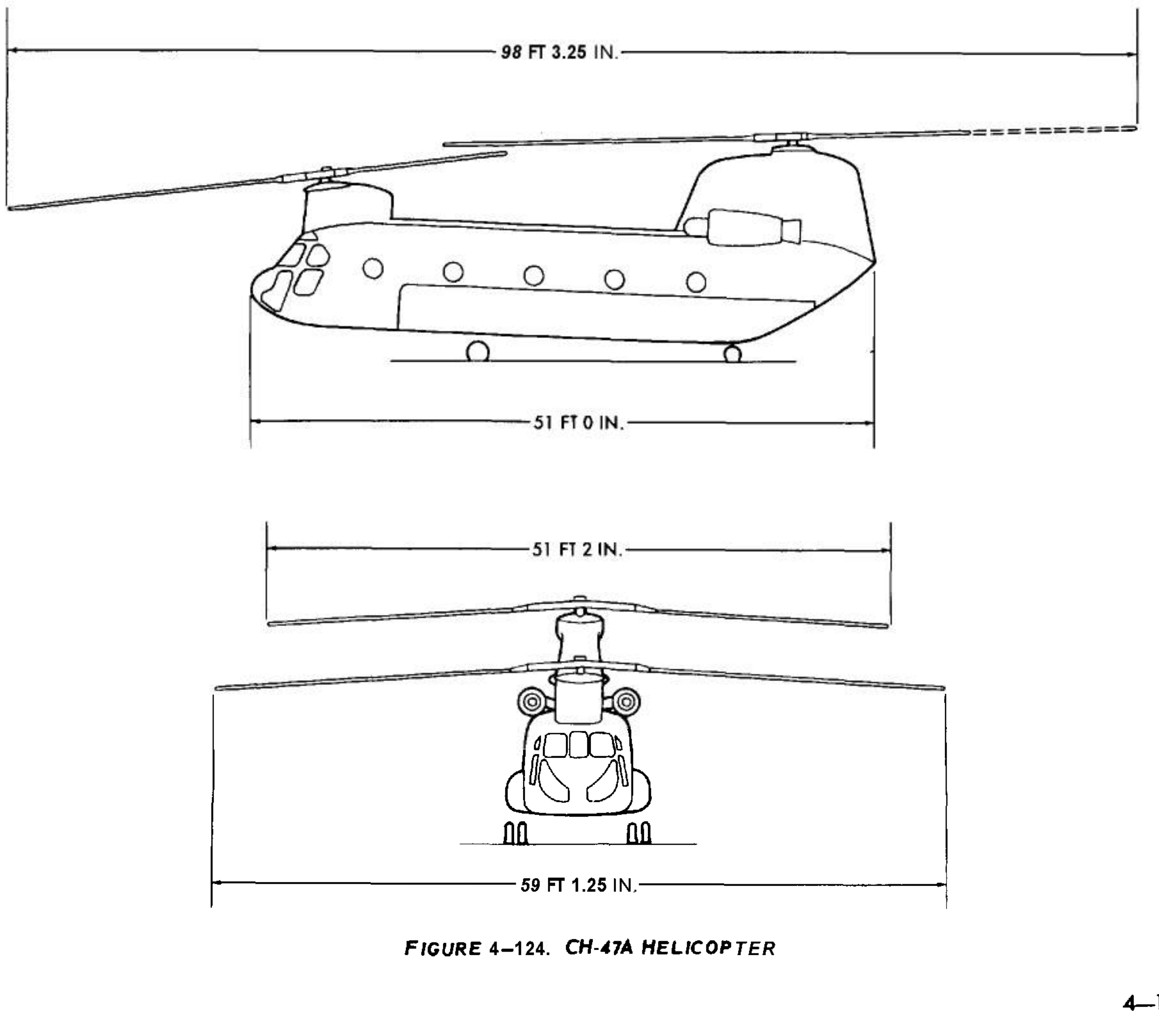


FIGURE 4–124. CH-47A HELICOPTER

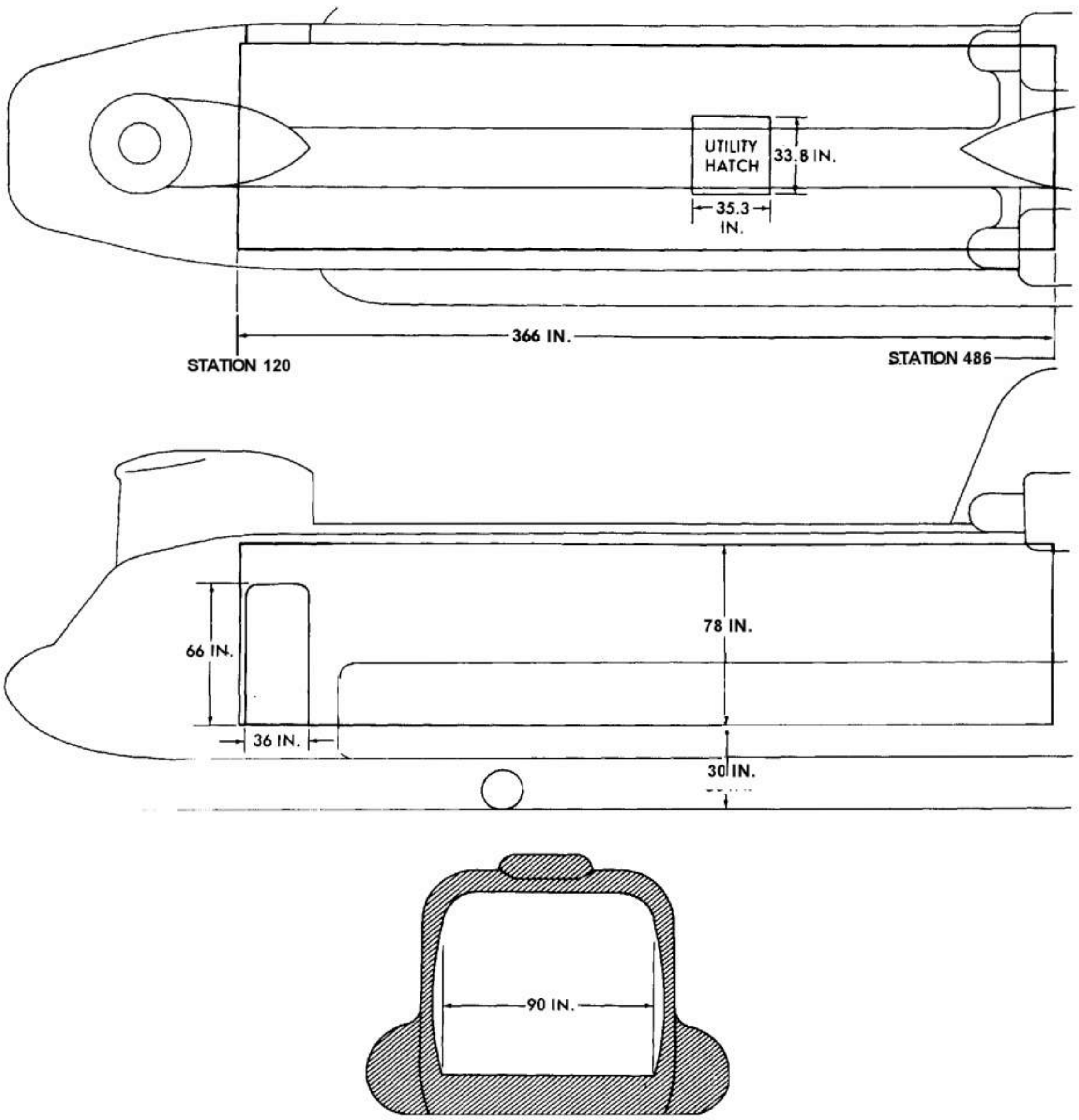
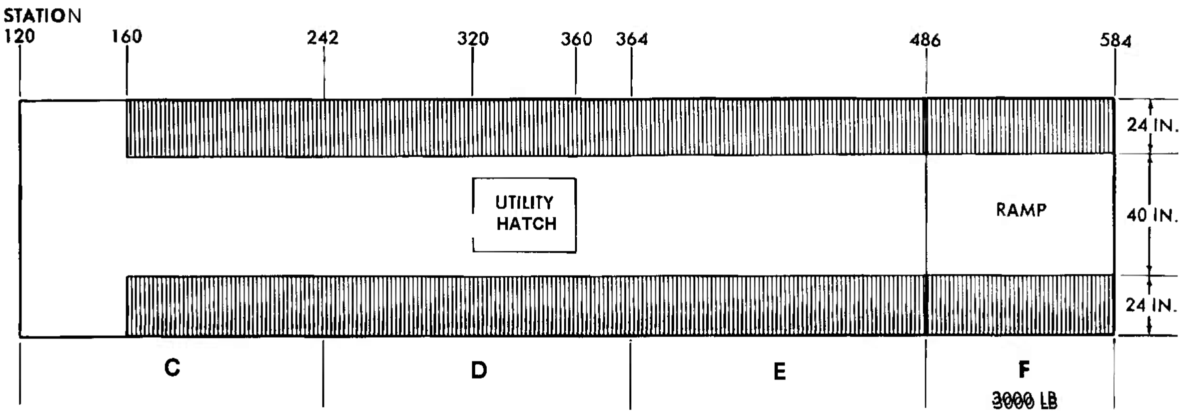


FIGURE 4-125. CARGO COMPARTMENT DIMENSIONS, CH-47A HELICOPTER

in Fig. 4—126. Compartments C, D, and E are designed to withstand distributed loads of 300 pounds per square foot. The loading ramp is limited to 300 pounds per square foot, not to exceed 3000 pounds total load. Treadway areas are designed to withstand concentrated loads of *2500* pounds (aft of station 160). Loads are limited to a concentrated load of 1000 pounds per square foot (local footprint pressure) for the remaining area of the cargo floor. Vehicles loaded on the treadways are limited to 75 pounds per square inch for pneumatic-tire wheel loads or *50* pounds per square inch



CODE	DISTRIBUTED LOAD (LB PER SQ FT)	CONCENTRATED LOAD (LB PER SQ FT)
TREADWAYS	300	2500
WALKWAY	300	1000

FIGURE 4-726. CARGO FLOOR AND RAMP WEIGHT LIMITS, CH-47A HELICOPTER

for solid-tire wheel loads. However, vehicles exceeding these limits may be loaded with the use of shoring.

4—1 17.2 ANCHORING ARRANGEMENT. There are eighty-seven 5000-pound capacity tie-down fittings (eighty-three in the fuselage floor and four in the ramp area) and eight 10,000-pound capacity tiedown fittings provided on the cargo floor. Four 10,000-pound capacity fittings are spaced along both outboard rows of 5000-pound capacity fittings at intervals of 80 inches. Tiedown fitting locations are shown in Fig. 4—127.

4—1 18 CARGO DOORS AND RAMPS

4—1 18.1 AFT CARGO DOOR AND RAMP. The aft cargo door and ramp is composed of an upper section (or door) and a lower section (or ramp) (Fig. 4—128). The door is an integral part of the ramp; it telescopes into the ramp when the ramp is being lowered and extends when the ramp is being raised. The ramp is hinged to the fuselage floor and opens outward and downward to rest on the ground. When lowered to ground position, the ramp inclines downward approximately 13 degrees. When it is

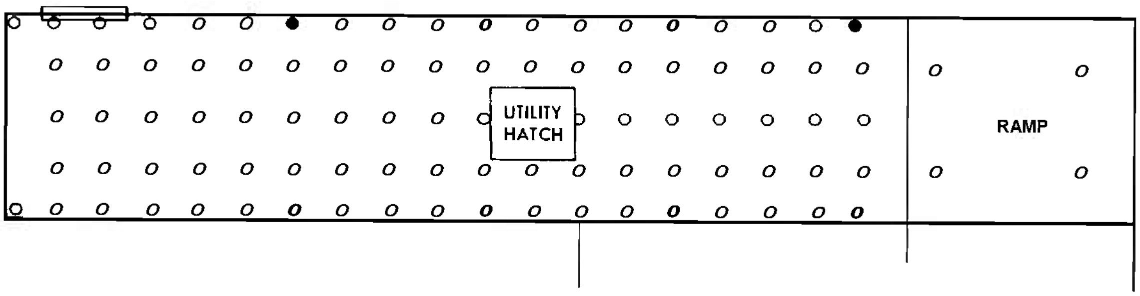


FIGURE 4-727. ANCHORING ARRANCEMENT, CH-47A HELICOPTER

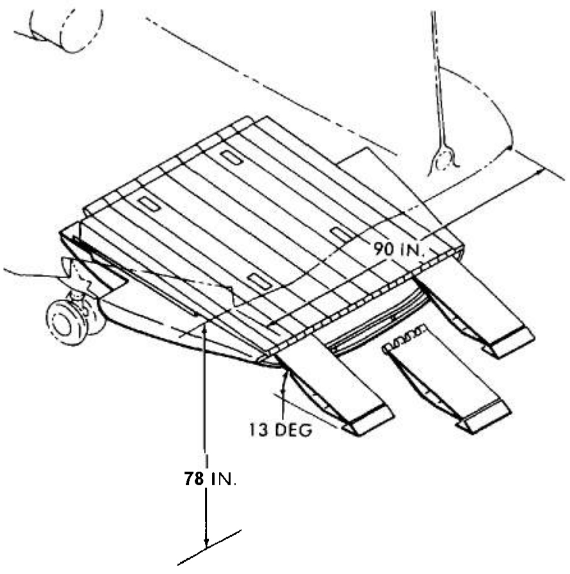


FIGURE 4-128. AFT CARGO DOOR AND RAMP, CH-47A HELICOPTER

raised, the ramp inclines upward 6 degrees from floor level. A continuous hinge extends the entire width of the upper edge of the ramp and is used to attach auxiliary loading ramps which bridge the gap between the ramp and the ground. These auxiliary ramps may be adjusted laterally to accommodate various vehicle tread widths. The door and ramp configuration provides a loading aperture 78 inches high and 90 inches wide for cargo loading. Maximum package size that can be loaded through the opening can be determined from Table 4-13.

4-118.2 MAIN ENTRANCE DOOR. The main entrance door is located on the right-hand side of the cargo compartment at the forward end (Fig. 4-125). The door is composed of two sections. The upper section rolls inward and upward to a position of overhead rest; the lower section opens outward and downward. When fully opened, the door space is limited to a 35-inch width by 63-inch height for cargo loading. Maximum package size that can be loaded through this opening can be determined from Table 4-14.

4-118.3 UTILITY HATCH AND RESCUE DOOR. The utility hatch door is made of sandwiched metal honeycomb material and is located in the center of the cargo compartment floor between stations 320 and 360 (Fig. 4-125). The door is hinged along its entire forward edge and opens upward and forward to expose the lower rescue door and cargo hook. The lower rescue door forms a part of the fuselage bottom when closed and is accessible through the utility hatch door.

4-119 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the CH-47A helicopter:

Forward	4.0
Aft	2.0
Side	1.5
Vertical	2.0

4-120 CARGO LOADING AND UNLOADING PROVISIONS

In addition to the auxiliary loading ramps, a 3000-pound capacity, hydraulically operated winch is permanently located on the floor at fuselage station 120. The winch, with the aid of pulley blocks, is capable of moving a 12,000-pound load up the ramp. It has two reeling speeds, one for cargo loading (20 feet per minute) and one for hoisting (100 feet per minute) through the utility hatch. The maximum hoisting load is 600 pounds.

TABLE 4–13. MAXIMUM AFT CARGO DOOR PACKAGE SIZE, CH-47A HELICOPTER

WIDTH (IN.)	HEIGHT (IN.)															
	62 AND UNDER	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
	MAXIMUM LENGTH (IN.)															
62 AND UNDER	362	362	362	362	362	362	362	362	330	282	230	180	135	100	67	30
63	362	362	362	362	362	362	362	362	328	280	228	178	133	98	66	
64	362	362	362	362	362	362	362	362	326	278	226	176	130	96	64	
65	362	362	362	362	362	362	362	362	322	274	222	173	127	93		
66	362	362	362	362	362	362	362	362	318	270	218	169	123	90		
67	362	362	362	362	362	362	362	362	313	266	214	165	119	86		
68	362	362	362	362	362	362	362	357	307	260	208	160	114	81		
69	362	362	362	362	362	362	362	348	299	252	201	154	107	75		
70	362	362	362	362	362	362	362	339	290	243	193	146	99			
71	362	362	362	362	362	362	362	330	281	234	185	139	91			
72	362	362	362	362	362	362	362	321	272	226	177	131	83			
73	362	362	362	362	362	362	352	312	263	216	167	122	75			
74	362	362	362	362	362	362	339	298	250	203	156	112				
75	362	362	362	362	362	362	325	284	237	190	144	101				
76	362	362	362	362	362	348	311	270	223	177	132	90				
77	362	362	362	362	362	334	297	256	209	164	119					
78	362	362	362	362	346	316	278	237	191	147	104					
79	362	362	362	362	329	298	258	218	173	129	85					
80	362	362	362	362	310	276	236	195	151	108						
81	362	362	362	362	289	253	213	172	128	85						
82	362	362	362	362	267	230	188	148	105							
83	362	362	362	362	241	202	161	121								
84	362	362	362	362	213	174	133	93								
85	362	362	362	362	182	142	100									
86	362	362	362	362	146	105										
87	362	362	362	362	105											
88	362	362	362	362												
89	362	362	362	362												
90	362															

TABLE 4-14. MAXIMUM MAIN ENTRANCE DOOR PACKAGE SIZE, CH-47A HELICOPTER

WIDTH (IN.)	HEIGHT (IN.)									
	53 AND UNDER	54	55	56	57	58	59	60	61	62
	MAXIMUM LENGTH (IN.)									
12	249	246	242	238	234	223	170	170	170	165
13	233	230	227	224	221	211	162	162	162	157
14	217	215	213	210	208	199	154	154	154	150
15	205	204	203	199	197	187	147	147	147	144
16	195	194	193	189	187	176	141	141	141	138
17	186	185	183	180	178	166	136	136	136	133
18	177	176	174	172	170	157	131	131	131	128
19	169	168	166	164	162	149	126	126	126	124
20	161	160	159	157	155	142	122	122	122	120
21	155	154	153	151	148	135	118	118	118	116
22	149	148	147	145	141	129	114	114	114	112
23	143	143	142	140	135	124	111	111	111	109
24	138	138	137	135	129	119	108	108	108	106
25	133	133	132	130	124	114	105	105	105	103
26	128	128	127	125	119	110	103	103	103	101
27	125	124	123	121	115	106	101	101	101	99

SECTION XXV

CH-54A

4—121 GENERAL DESCRIPTION

The CH-54A (Fig. 4—129) is a twin-turbine, single-main-rotor, antitorque-tail-rotor helicopter designed in a crane configuration to externally transport loads up to 12 tons. Its main rotor, consisting of six blades, has a diameter of 72 feet. The 19-foot, 9-inch-wide landing gear provides a ground clearance of 9 feet 4 inches. The **CH-54A** is equipped with cargo shackles at hardpoints on the fuselage for attachment of cargo or cargo-carrying pods, a cargo hoist system, and either a cargo load leveling system or a four-point cargo suspension system. Application of the cargo pods could be as airborne field hospitals, machine shops, communication centers, command posts, or any other mobile unit. The CH-54A can retrieve any disabled fixed-or rotary-wing Army aircraft; thus, one of its prime missions is to evacuate aircraft or other repairable equipment.

4—122 CARGO HOIST SYSTEM

The cargo hoist system consists of a four-point hoist system and a single-point suspension system. The CH-54A is capable of transporting an external load approximately 7 x 7 x 12 feet up to 115 knots on the four-point suspension system or up to 70 knots on the single-point suspension system. The four-point hoist system consists. of four 6000-pound-capacity hoists mounted on the sides of the fuselage. Each hoist, having 50 feet of cable and a damping device to isolate helicopter or load vibration, can be operated collectively or individually. As a result, a ground crew can load or unload cargo while the helicopter is hovering.

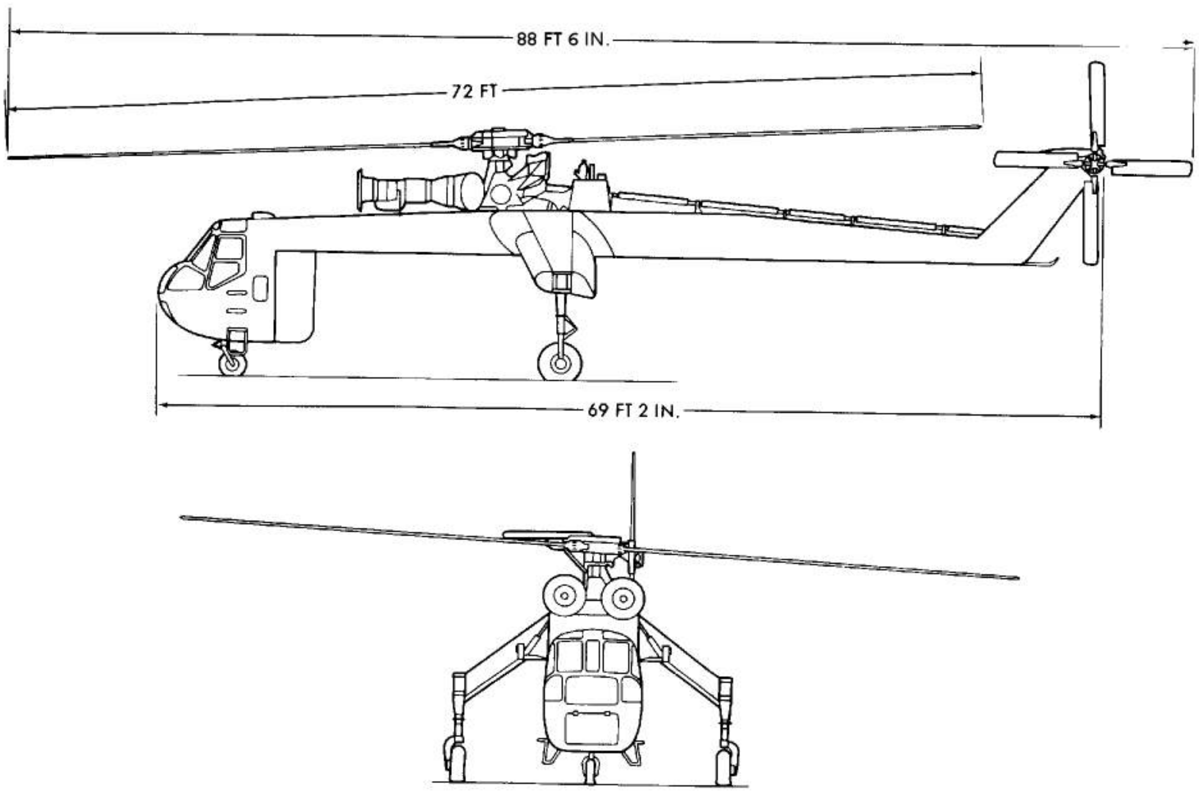


FIGURE 4–129. CH-54A HELICOPTER

The single-point suspension system features a 15,000-pound capacity, hydraulically operated hoist and cargo hook that can raise and lower a load through 100 feet of travel at the rate of 50 feet per minute. When a load is lowered to the ground, it can be released automatically by a quick-release hook. It can also be released manually on the ground or released electrically by the pilot. Should it become necessary, a built-in guillotine can be actuated to jettison the load. Space and structural provisions allow for incorporation of a 20,000-pound-capacity cargo sling assembly.

SECTION XXVI

DC-7BF

4—123 GENERAL DESCRIPTION

The Douglas **DC-7BF** is a four-engine, low-wing monoplane with a fully retractable landing gear (Fig. **4—130**). It is designed as a long-range air-freighter, capable of carrying a payload of **35,988** pounds. It is similar to the **C-118/DC-6B** aircraft described in Section V, having slightly different dimensions and a roller conveyor system for cargo loading.

4—124 CARGO COMPARTMENT

The **DC-7BF** has three separate cargo compartments: main, lower forward, and lower aft. Dimensions of the cargo compartment are shown in Fig. **4—131**. The main cargo compartment is **855-1/4** inches long, **93** inches high, and 105 inches wide at floor level. The lower forward cargo compartment is **251-3/8** inches long, **72-3/4** inches wide, and **30-1/2** inches high. The lower aft cargo compartment is **378** inches long, **74-1/4** inches wide, and **31-1/2** inches high.

4—125 CARGO DOORS

The **DC-7BF** aircraft has four cargo doors. The **DC-7BF** cargo doors are identical in location and dimensions to the cargo doors installed on the **C-118/DC-6B** aircraft described in Section V.

4—126 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the **DC-7BF** aircraft:

Forward	6.00
Aft	1.29
Side	1.50
Vertical	2.00

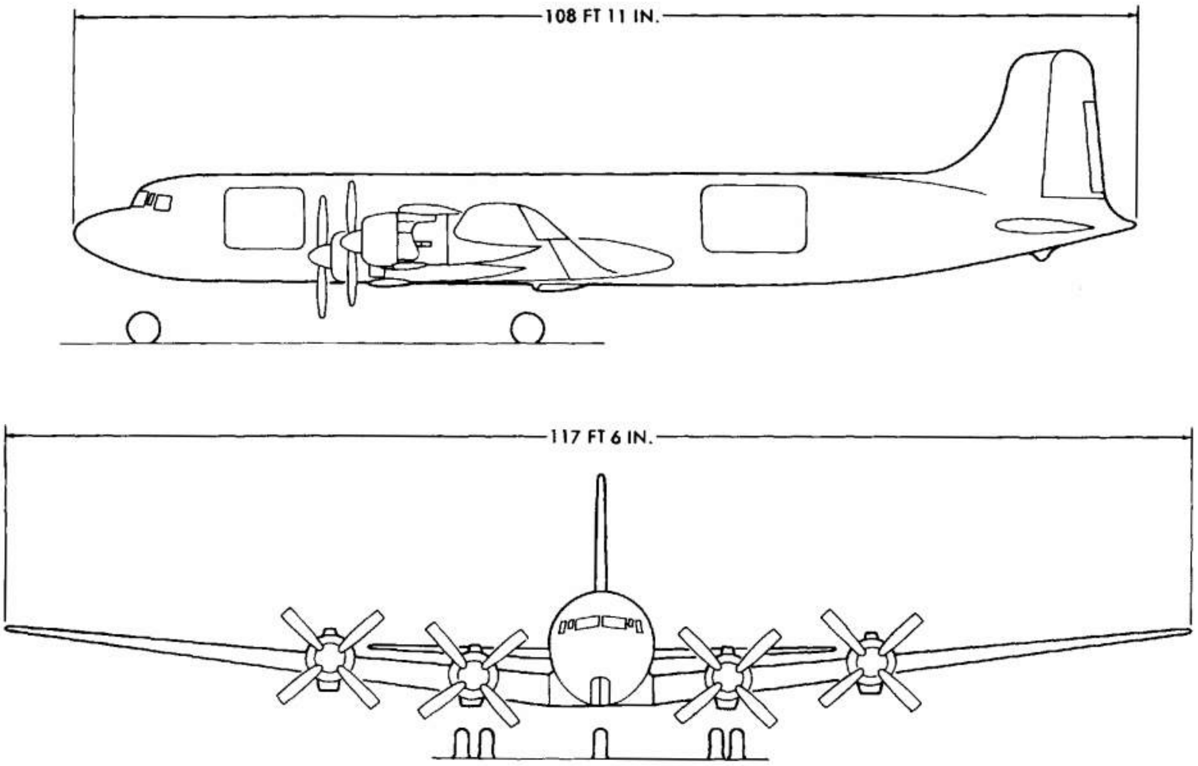


FIGURE 4–130. DC-7BF AIRCRAFT

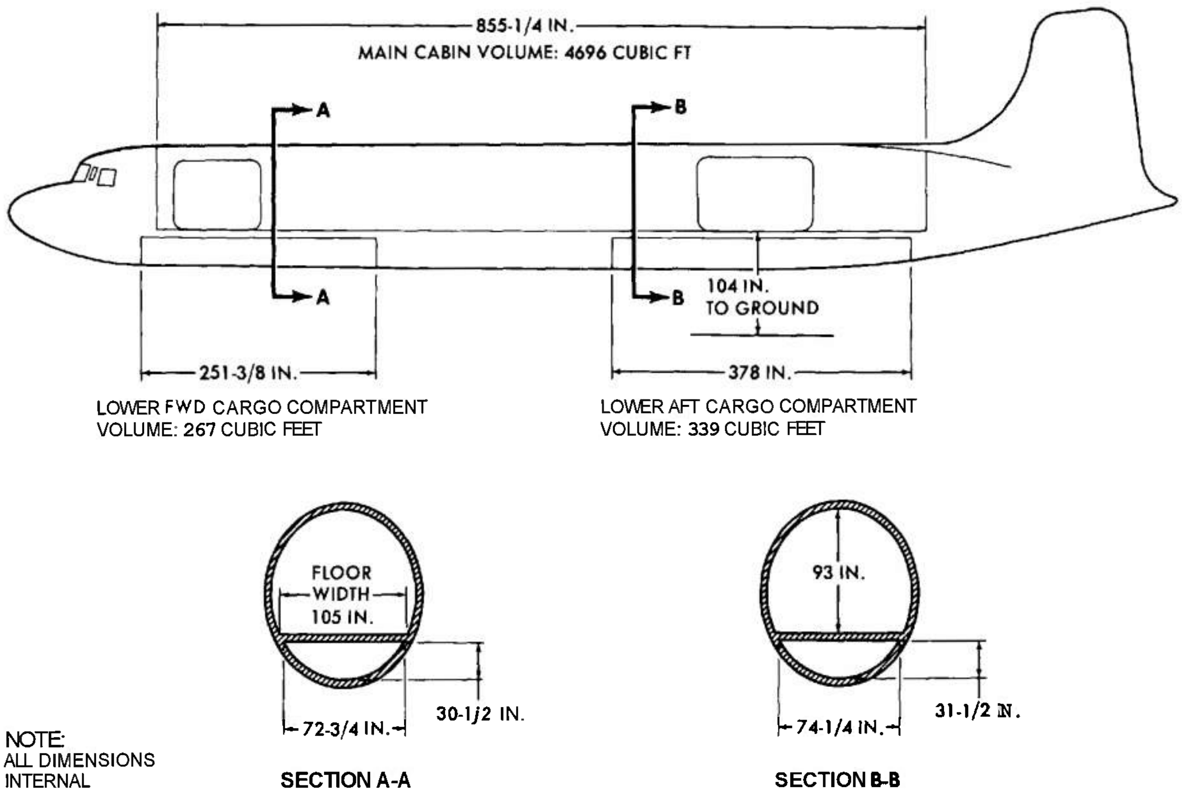


FIGURE 4-131. CARGO COMPARTMENT DIMENSIONS AND CAPACITIES, DC-7BF AIRCRAFT

4—127 CARGO LOADING AND UNLOADING PROVISIONS

The DC-7BF cargo loading system includes roller conveyors, guides, a ball mat system for door sills, and removable pallet down locks for loading, restraining, and unloading of palletized cargo. The system is compatible with 54 by 88-inch, 108- by 88-inch, and 125- by 88-inch pallets, or any combination of these sizes.

The roller conveyors are located directly over the longitudinal floor support beams. The load carrying members of the conveyor system are attached to floor pan fittings which are located on approximately 20-inch centers. The removable pallet down locks allow for positioning of different-sized pallets in the same load. The locks provide forward and aft restraint by engaging the forward and aft edges of the pallets. Lateral restraint is provided by the side rails.

SECTION XXVII

DC-8F

4—128 GENERAL DESCRIPTION

The DC-8F is a low wing, four fan jet engine, heavy transport (Fig. 4—132). It is designed as a long-range combination cargo/passenger transport. Special features of the DC-8F are a cargo system compatible with a wide variety of pallets, both military and civil; divider partitions capable of being installed at any of ten positions; and a pressurized and air-conditioned cargo compartment.

4—129 CARGO COMPARTMENT

The main cargo compartment extends from station 292 to station 1566. Some DC-8F aircraft have removable lavatories installed between stations 1488 and 1566. In a mixed cargo/passenger version, a removable partition, to separate cargo and passengers, may be installed at any of 10 positions from station 559 to station 1360. Volume of the main cargo compartment is 7056 cubic feet. Critical contours of the main cargo compartment are shown in Fig. 4—133.

The lower forward cargo compartment extends from station 310 to station 640 and has a volume of 690 cubic feet.

The lower aft cargo compartment extends from station 980 to station 1337 and has a volume of 700 cubic feet.

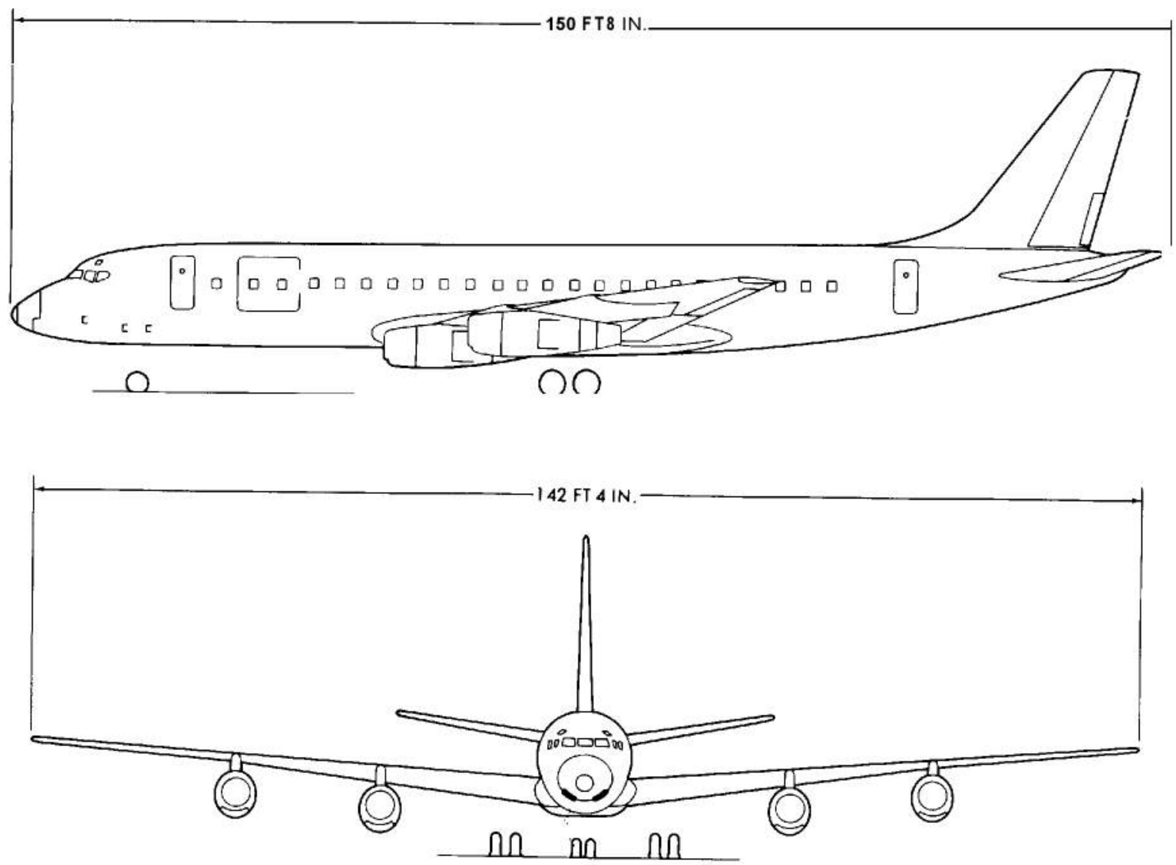
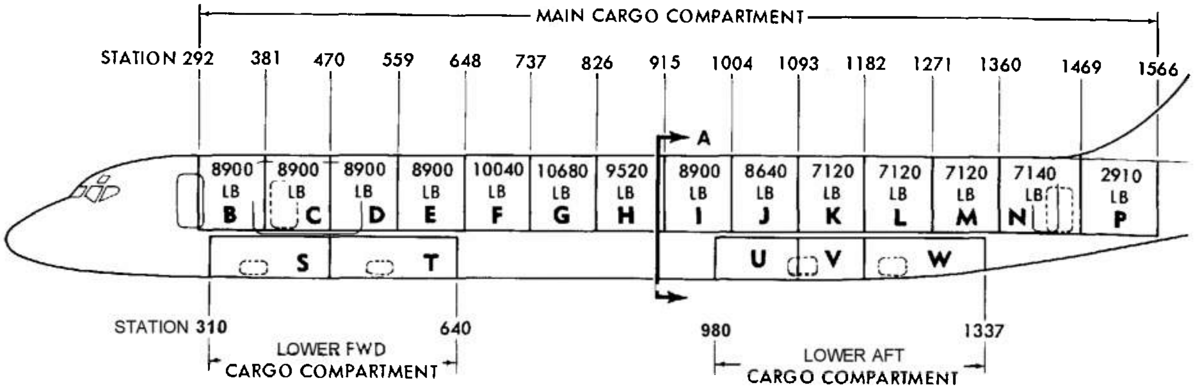
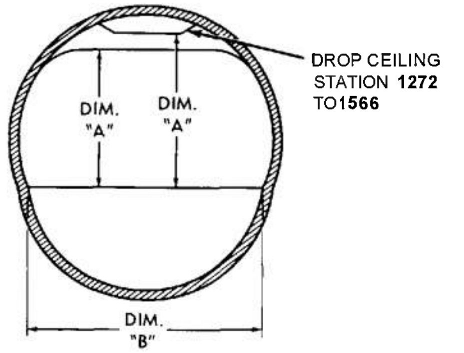


FIGURE 4–132. DC-8F AIRCRAFT





SECTION A-A

STATION	DIM. A CEILING HEIGHT	DIM. B FLOOR WIDTH
FWD SECTION 302	85.6 85.6	125.4 126.0
CONSTANT SECTION 360-1226 1226-1310	85.6 80.9	127.2 127.2
AFT SECTION 1488	80.9	85.8

INTERIOR DIMENSIONS

NOTES:

1. THE CAPACITY OF COMPARTMENT N MUST BE DECREASED BY ANY WEIGHT TO BE CARRIED IN COMPARTMENT P.
2. LOADS SHOWN ARE ALSO FUSELAGE SHELL LIMITATIONS. THE CAPACITIES OF EACH OF THE UPPER COMPARTMENTS MUST INCLUDE THE WEIGHTS OF THE CORRESPONDING AREA DIRECTLY BELOW.
3. ON SOME AIRCRAFT THE AFT LIMIT OF THE CARGO COMPARTMENT IS REDUCED TO STATION 1488 WHEN THE LAVATORIES ARE INSTALLED.

FIGURE 4-733. CARGO COMPARTMENT DIMENSIONS AND WEIGHT LIMITS, DC-OF AIRCRAFT

4—129.1 FLOOR LOADING. The main cargo compartment floor is constructed of heavy duty, aluminum alloy planking. Maximum floor loading is **300** pounds per square foot for the main cargo floor and **120** pounds per square foot for the lower cargo floor. Individual cargo compartment maximum weight limits are shown in Fig. **4—133.** Table **4—15** provides allowable wheel load ratings for steel wheels in contact with the cargo floor.

4—129.2 ANCHORING ARRANGEMENT. Tiedown tracks of 5000-pound capacity at any one point are installed in the main cargo floor (Fig. **4—134).** Removable tiedown rings can be installed in the track at 20-inch intervals. Additional tiedown rings may be installed on top of the siderails of the multipallet loading system, with an allowable load of **2400** pounds in any direction. Palletized cargo is restrained by adjustable siderails and end restraint fittings.

WHEEL WIDTH (IN.)	WHEEL DIAMETER (IN.) 4	6	8	12
	IN FLIGHT, STATION 292 TO 1014 (LB)			
1	1310	1350		
3	1370	1560	1600	1660
3 DUAL	1540	1750	1800	1870
	IN FLIGHT, STATION 1014 TO 1478 (LB)			
1	1110	1140		
3	1160	1320	1350	1400
3 DUAL	1310	1490	1520	1580
	LOADING AND POSITIONING (LB)			
1	2280	2330		
3	2380	2700	2780	2890
3 DUAL	2680	3040	3130	3250

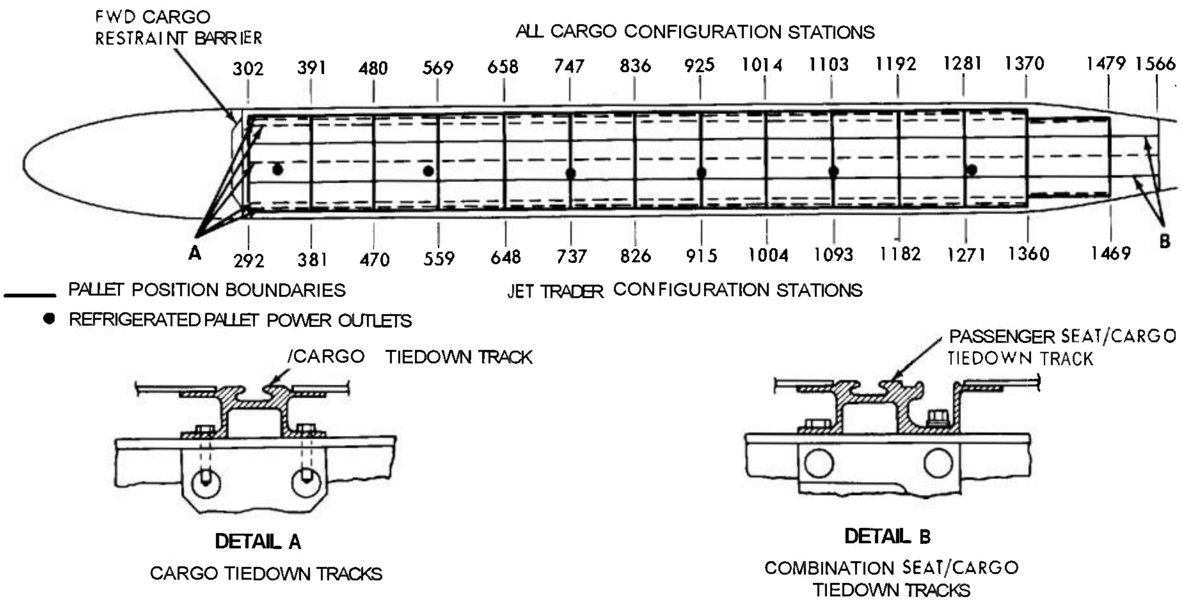


FIGURE 4–134. ANCHORING ARRANGEMENT, DC-8F AIRCRAFT

4—130 CARGO DOORS

The aircraft has five cargo doors, one in the main cargo compartment and four in the lower cargo compartments.

The main cargo door, located between station 370 and 510 on the left side of the fuselage, is 85 inches high and 140 inches wide. The maximum size cargo package that may be loaded through the main cargo door may be determined from Table **4—16.** To use the table, find the smallest dimension (height) of the package to be loaded in the left-hand vertical column. **If** the exact dimension is not shown, use the next higher dimension. **Find** the next larger (width) dimension in the upper horizontal

HEIGHT (IN.)	WIDTH (IN.) 6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	128
	MAXIMUM LENGTH (IN.)																				
6 to 48	1170	861	688	566	478	414	367	330	299	272	249	230	213	199	186	176	165	158	151	146	140
54	1128	830	660	547	463	403	359	323	293	266	245	226	210	196	184	174	164	157	149	144	
60	1012	738	600	503	433	383	342	308	280	257	237	220	206	192	181	171	162	154	147	140	
66	760	630	520	445	389	346	312	283	259	239	221	206	193	183	171	161	152	144			
72	629	518	441	385	340	305	278	253	233	216	202	189	178	167	157	148	140				
78	496	421	366	327	294	267	245	226	209	195	182	170	160	149	140						
84	369	325	291	263	239	219	202	188	174	161	148	136									

TABLE 4–17. MAXIMUM PACKAGE SIZE, LOWER FORWARD CARGO COMPARTMENT FORWARD DOOR, DC-8F AIRCRAFT

WIDTH (IN.)	HEIGHT (IN.) 12	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	33	36	39	41
	MAXIMUM LENGTH (IN.)																				
12	210	202	202	199	196	193	191	189	186	183	180	170	165	160	140	136	130	102	99	82	80
15	202	172	159	152	144	134	129	127	124	122	120	118	115	113	112	111	110	102	77	40	
16	199	160	150	139	127	125	124	122	120	118	116	114	113	112	111	110	106	101	76	40	
17	197	150	140	130	122	120	118	117	116	114	111	110	110	107	107	105	103	77	75	40	
18	196	144	127	122	120	118	116	115	114	112	109	108	108	107	105	103	101	78	73	40	
19	193	134	125	121	118	116	115	114	112	109	106	105	105	105	103	102	100	78	73	40	
20	191	130	123	120	114	113	112	110	108	106	103	103	103	103	102	101	100	77	72	40	
21	189	127	122	117	111	110	110	108	106	104	103	103	102	102	101	100	100	76	72	40	
22	185	125	120	115	110	108	108	106	105	104	103	102	101	101	100	99	79	75	71	40	
23	182	122	118	112	109	107	105	105	104	104	102	102	101	101	100	99	99	75	70	40	
24	180	120	116	111	109	106	103	103	103	103	102	101	101	100	77	79	99	74	88	40	
25	170	118	115	110	108	105	103	103	103	103	102	101	100	100	77	77	77	74	88	40	
26	164	115	113	109	107	104	103	102	102	102	101	101	100	77	77	78	78	74	87	40	
27	160	113	112	108	106	103	102	102	102	102	101	100	100	77	99	98	78	74	86	40	
28	140	111	110	107	105	103	101	101	101	101	101	100	100	77	77	78	77	73	85	40	
29	121	108	107	106	104	102	101	101	101	101	101	100	100	77	77	78	77	72	84	37	
30	109	106	105	105	104	102	101	101	101	101	101	100	100	77	97	78	97	91	83	38	
31	106	104	104	103	102	101	99	98	97	77	77	96	76	76	75	95	95	87	73		
32	103	103	102	101	100	79	98	97	76	76	75	95	74	74	93	93	73	87	62		
33	102	102	101	99	78	78	97	96	75	95	74	74	74	74	73	72	71	85			
34	102	101	100	78	77	76	7s	74	74	73	92	91	91	90	87	88	87	81			
35	101	97	78	77	96	95	94	74	73	72	91	90	89	89	87	86	85				
36	98	97	96	95	74	93	92	72	91	70	87	88	87	86	85	84	83				

column. Proceed horizontally from the first dimension and vertically from the second dimension to find the maximum permissible third dimension (length).

Four cargo doors provide access to the two lower cargo compartments. Each of the four doors, located on the right side of the aircraft, are 36 inches by 44 inches. Tables 4—17 through 4—20 indicate maximum package size for loading through the four doors.

4—131 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the DC-8F aircraft:

Forward	1.5
Aft	1.5
Side	1.5
Vertical	2.6 to **4.05**

A restraint factor of 2.6 g's vertical is applicable from station 292 to station 925 and increases linearly from 2.6 g's at station 925 to 4.05 g's at station 1566 (Fig. 4—135). A restraint net for a 96,000-pound cargo load is installed at station 292 to provide restraint for crash load factors of 9 g's.

4—132 CARGO LOADING AND UNLOADING PROVISIONS

The aircraft is available with a lightweight loading system and a multipallet loading system. The lightweight loading system is a low-friction, nonpowered conveyor that will receive pallets or containers at the cargo loading door and carry them the full length of the cargo compartment. The multipallet loading system incorporates adjustable side rails and flip-up restraint fittings. The system will accommodate most commercial pallets and the 88- by 54-inch and 88- by 108-inch HCU 10/C and 6/E military pallets.

WIDTH (IN.)	12	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	33	36	39	41
	MAXIMUM LENGTH (IN.)																				
12	208	192	190	188	186	163	150	148	147	146	145	142	138	131	130	130	130	105	99	52	80
15	170	141	139	137	135	133	129	127	127	127	127	127	125	123	118	115	112	102	97	40	
16	167	138	138	135	134	131	128	126	126	125	125	125	124	122	117	113	111	101	96	40	
17	163	136	136	134	132	129	127	125	125	124	123	122	120	118	116	112	111	99	95	40	
18	160	135	135	133	131	128	126	124	124	123	122	121	119	117	115	111	111	98	93	40	
19	158	131	130	130	129	127	125	123	122	121	121	120	118	115	113	111	110	98	93	40	
20	156	128	127	127	126	125	124	122	121	120	118	116	115	113	112	110	110	97	92	40	
21	154	126	125	125	125	124	124	121	120	118	115	114	113	112	111	110	110	96	92	40	
22	150	125	123	123	123	122	122	121	119	116	114	113	112	111	110	109	109	95	91	40	
23	147	124	120	120	119	119	118	117	116	114	113	112	111	110	110	108	108	95	90	40	
24	142	122	119	118	117	116	115	114	113	112	111	111	110	109	109	108	108	94	88	40	
25	139	119	118	117	116	114	113	112	111	110	109	109	109	108	107	106	106	94	88	40	
26	134	117	116	115	114	113	111	110	109	108	108	107	107	106	105	104	103	94	87	40	
27	131	115	114	113	112	110	108	107	107	107	107	107	107	104	103	102	102	94	86	40	
28	128	113	112	110	109	108	107	106	105	105	105	105	105	103	102	101	100	93	85	40	
29	126	111	110	109	108	107	106	105	104	103	103	102	102	101	100	99	98	92	84	39	
30	125	110	109	109	107	107	105	104	103	102	102	101	100	100	99	98	77	91	83	38	
31	123	107	105	103	102	101	100	99	99	99	99	99	98	97	96	96	95	89	73		
32	120	103	102	101	100	99	97	97	96	96	95	95	94	94	94	94	93	87	62		
33	105	102	101	99	98	98	97	96	95	95	94	94	94	94	93	92	91	85			
34	102	101	100	98	97	96	94	94	94	93	92	91	91	90	89	88	86	80			
35	101	99	98	97	96	95	94	94	93	92	90	90	89	89	87	86	85				
36	99	97	96	95	93	93	92	92	91	90	88	88	87	81	78	53	41				

TABLE 4–19. MAXIMUM PACKAGE SIZE, LOWER AFT CARGO COMPARTMENT FORWARD DOOR, DC-8F AIRCRAFT

	HEIGHT (IN.)																		
	12	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	33	36
WIDTH (IN.)	MAXIMUM LENGTH (IN.)																		
12	160	158	156	155	154	153	153	152	152	152	152	151	149	148	144	136	130	103	96
15	153	151	150	148	146	144	143	143	142	142	142	142	141	140	132	124	114	102	42
16	153	150	149	146	145	143	141	140	140	139	139	137	134	133	127	119	113	101	42
17	152	150	148	145	143	141	138	137	137	136	136	135	130	126	123	116	112	99	42
18	152	149	148	143	141	139	136	135	135	134	134	132	127	120	118	114	112	98	42
19	151	149	147	140	138	137	134	133	131	130	128	125	122	118	115	113	111	97	42
20	151	149	146	139	136	134	131	130	127	125	123	121	120	116	114	111	110	96	42
21	150	149	1.44	139	135	132	129	128	126	123	120	118	116	115	112	110	109	96	42
22	149	147	143	139	135	132	127	125	123	120	118	116	114	113	109	108	107	95	42
23	147	146	141	138	134	131	126	123	120	118	115	113	111	110	107	106	105	95	42
24	146	146	140	138	134	131	125	120	117	115	113	112	108	108	106	104	103	94	42
25	145	145	138	136	131	128	123	118	115	112	111	110	108	107	105	103	102	94	42
26	144	144	137	132	127	123	119	116	112	110	109	108	107	105	103	102	101	94	42
27	143	143	131	125	120	117	114	112	110	108	107	107	107	104	102	101	101	94	42
28	138	133	125	121	117	115	111	109	107	106	103	101	100	100	99	98	98	80	39
29	124	122	119	118	114	112	109	107	105	103	101	99	98	97	97	96	96	76	
30	118	109	107	106	105	104	103	102	101	100	99	98	97	96	95	94	94	73	
31	114	107	105	104	103	101	100	99	98	98	97	96	95	94	91	87	84	69	
32	111	106	103	102	101	99	98	97	96	96	95	95	94	94	85	82	78	65	
33	108	103	101	100	99	98	97	96	95	95	94	94	94	94	80	76	73	47	
34	101	100	99	98	97	95	94	93	90	88	86	84	82	78	71	64	59	44	
35	99	98	97	96	76	92	92	92	88	85	82	80	77	75	63	57	50		
36	96	95	94	93	92	89	88	87	83	81	78	65	60	58	55	48	37		

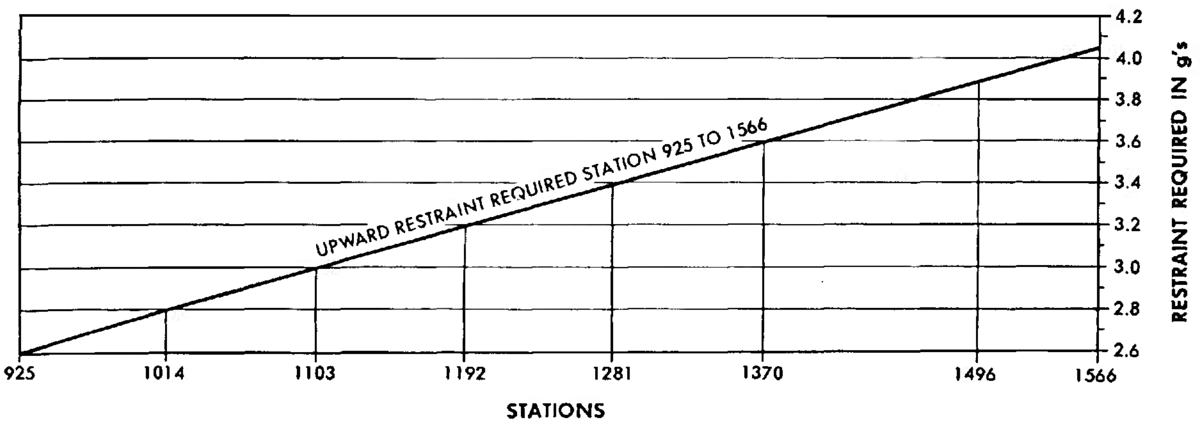


FIGURE 4–135. VERTICAL RESTRAINT REQUIREMENTS, DC-8F AIRCRAFT

TABLE 4–20. MAXIMUM PACKAGE SIZE, LOWER AFT CARGO COMPARTMENT AFT DOOR, DC-8F AIRCRAFT

	HEIGHT (IN.)																		
	12	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	33	36
WIDTH (IN.)	MAXIMUM LENGTH (IN.)																		
12	240	220	214	208	202	198	188	185	184	183	181	179	177	168	166	165	164	99	89
15	212	175	171	167	163	161	159	156	154	152	150	150	150	150	142	126	119	96	82
16	200	173	169	164	161	159	153	150	148	147	146	145	143	141	131	123	117	96	52
17	195	171	166	162	158	156	147	142	140	139	138	137	135	133	123	120	114	96	52
18	192	168	164	161	157	154	141	139	138	137	136	130	128	126	120	117	112	96	52
19	190	163	162	159	153	150	138	135	133	132	131	129	126	125	118	115	111	96	52
20	183	159	155	153	148	145	133	130	130	129	129	127	123	121	117	111	109	96	52
21	180	157	154	150	146	142	128	128	128	128	128	126	121	115	113	109	107	96	52
22	179	156	152	148	144	139	126	124	122	121	120	117	114	112	110	107	105	96	52
23	178	155	150	146	142	137	123	120	118	117	116	115	112	109	108	106	103	96	52
24	178	154	148	144	139	136	121	117	115	114	113	111	109	107	106	104	102	96	52
25	178	150	146	140	133	125	118	115	113	112	110	108	107	105	104	103	101	96	52
26	177	147	142	133	129	120	115	113	111	110	108	106	105	103	102	101	100	96	52
27	177	144	138	131	126	117	112	110	109	107	106	105	104	102	101	100	99	96	52
28	169	124	120	116	114	110	108	107	106	105	104	103	102	101	100	98	96	93	49
29	166	113	112	110	109	106	105	105	104	104	103	102	101	100	99	96	93	87	44
30	165	108	107	106	106	104	103	102	101	101	100	100	99	99	98	94	92	76	38
31	156	106	105	104	103	102	100	99	99	98	98	97	97	97	96	90	88	60	
32	132	103	102	101	100	99	98	98	98	97	97	96	96	95	93	88	85	54	
33	101	99	98	98	97	97	97	96	95	95	94	94	93	91	90	86	83	46	
34	100	97	96	95	94	93	92	91	90	89	89	88	88	88	85	75	72	39	
35	96	95	94	93	93	91	90	90	89	88	88	87	87	87	73	68	65		
36	89	86	85	84	83	80	79	77	75	74	72	69	69	68	54	42	39		

SECTION XXVIII

707-320C

4—133 GENERAL DESCRIPTION

The Boeing 707-320C is a four-engine, long-range, low swept-back wing transport (Fig. 4—136). The aircraft may be used in a passenger, cargo, or combination passenger/cargo configuration. The aircraft has an operating weight empty of 140,000 pounds and a maximum takeoff weight of 328,000 pounds. The maximum payload is 56,900 pounds.

4—134 CARGO COMPARTMENT

The 707-320C has three cargo compartments: main, lower forward, and lower aft. The main cargo compartment is 1326 inches long, 139 inches wide, and 91 inches high (Fig. 4—137). It has a volume of 8150 cubic feet and will accommodate thirteen 88-inch by 100-inch or twelve 88-inch by 125-inch pallets and one 88-inch by 108-inch pallet. Total pallet volume with 108-inch pallets is 5020 cubic feet. Total pallet volume with 125-inch pallets is 5776 cubic feet. The lower forward cargo compartment has a capacity of 800 cubic feet. The lower aft cargo compartment has a capacity of 900 cubic feet. Pallet restraining nets are provided to secure cargo to pallets. The cargo handling system includes pallet locks for securing pallets in the aircraft. In addition, a barrier net capable of restraining 90,000 pounds of cargo at 9 g's can be attached at the forward end of the main cargo compartment.

4—135 CARGO DOORS

The main cargo door is located on the left side of the fuselage forward of the wing

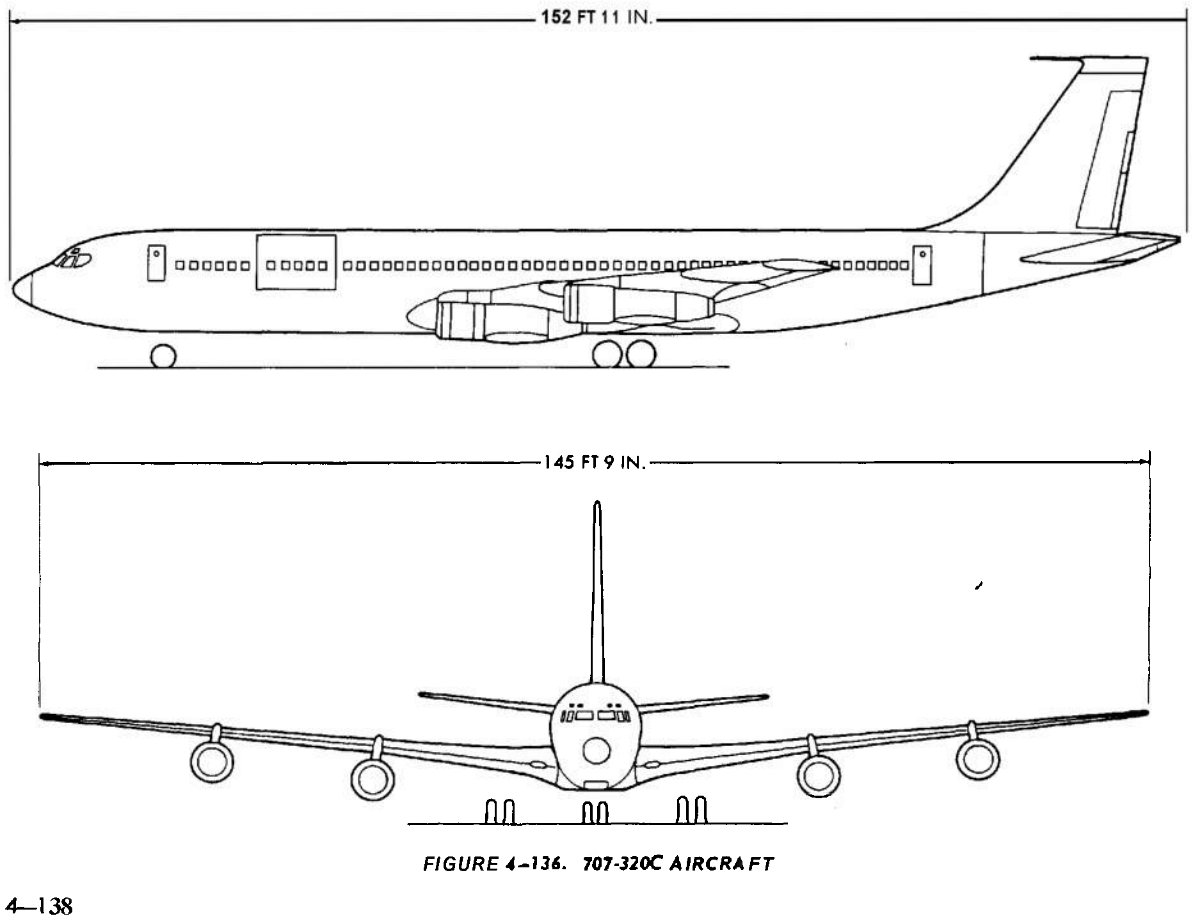


FIGURE 4–136. 707-320C AIRCRAFT

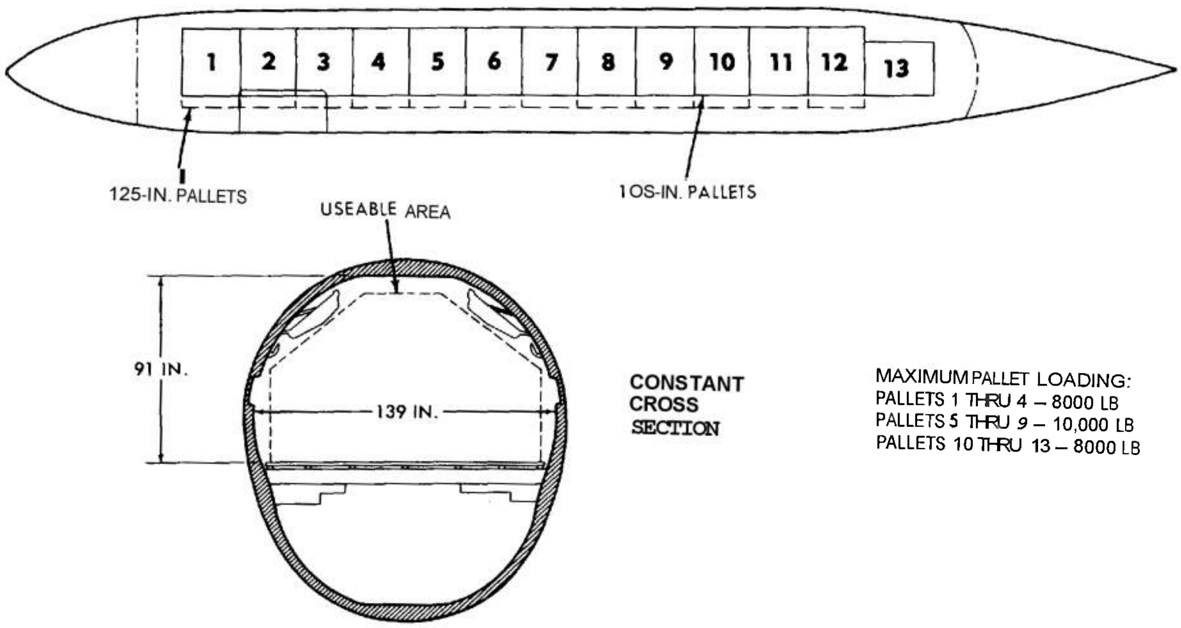


FIGURE 4–137. MAIN CARGO COMPARTMENT, 707-320C AIRCRAFT

(Fig. 4–138). The door sill is at floor height to facilitate pallet loading. The main cargo door can be opened to two positions. With the door in the fully open position, large packages can be crane-lifted and lowered vertically into the aircraft. The door is stopped and held automatically in the canopy position for loading palletized cargo.

One cargo door for the lower forward cargo compartment and two cargo doors for the lower aft cargo compartment are located on the right side of the aircraft fuselage. The lower forward cargo compartment door is 48 inches wide by 50 inches high. The lower aft cargo compartment forward door is 48 inches wide by 49 inches high. The lower aft cargo compartment aft door is 30 inches wide by 35 inches high.

4–136 RESTRAINT CRITERIA

The following restraint factors in g's are applicable to the 707-320C aircraft:

Forward	9.0
Down	4.5
Side	1.5
Vertical	2.0

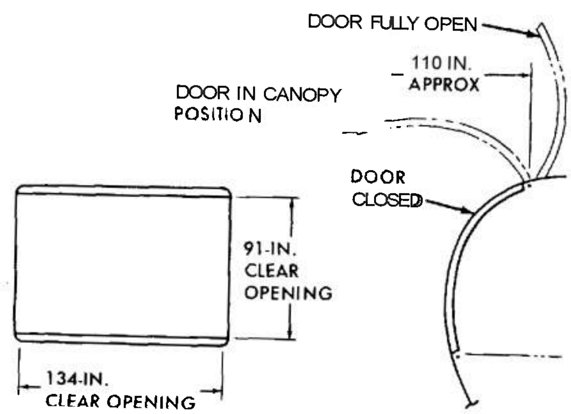


FIGURE 4–138. MAIN CARGO COMPARTMENT DOOR, 707-320C AIRCRAFT

4–137 CARGO LOADING AND UNLOADING PROVISIONS

The cargo handling system attaches to the seat tracks of the aircraft and consists of the following components: conveyor system, ball transfer panel, pallet assemblies, pallet locks, pallet restraining nets (attach to four corners of pallet), pallet brakes, and door roller guides. Provisions for attaching cargo barrier nets are included in the conveyor system.

SECTION XXIX

727C AND 727QC

4—138 GENERAL DESCRIPTION

The Boeing 727C (Convertible) and 727QC (Quick Change) are three-engine, low-wing, short- to medium-range aircraft, capable of transporting personnel or cargo (Fig. 4—139). The 727QC is designed primarily as an all passenger or all cargo carrier. The 727C will carry a mixed passenger/cargo load. The total payload capacity of the basic aircraft is 38,290 pounds. An increased gross weight option permits a payload of 46,790 pounds.

4—139 CARGO COMPARTMENT

The 727C and 727QC have three cargo compartments: main, lower forward, and lower aft. The main cargo compartment is 86 inches high and will accommodate eight 88-inch by 108-inch or eight 88-inch by 125-inch pallets (Fig. 4—140). Maximum pallet volume is 365 cubic feet for each 108-inch pallet and 405 cubic feet for each 125-inch pallet. In addition, the 727C is capable of carrying unpalletized bulk cargo, including wheeled vehicles. The lower forward and aft cargo compartments have a combined capacity of 890 cubic feet (Fig. 4—141).

4—139.1 FLOOR LOADING. Lateral floor support is provided by transverse floor beams located coincident with body frames (Fig. 4—142). A fore-and-aft floor beam at the aircraft centerliie serves to distribute concentrated floor loads into several transverse floor beams. Upper surface floor panels are made of lightweight aluminum sheet and are attached by spotwelds to formed aluminum sheets that comprise the lower surface. During loading and unloading, a maximum allowable upper deck static

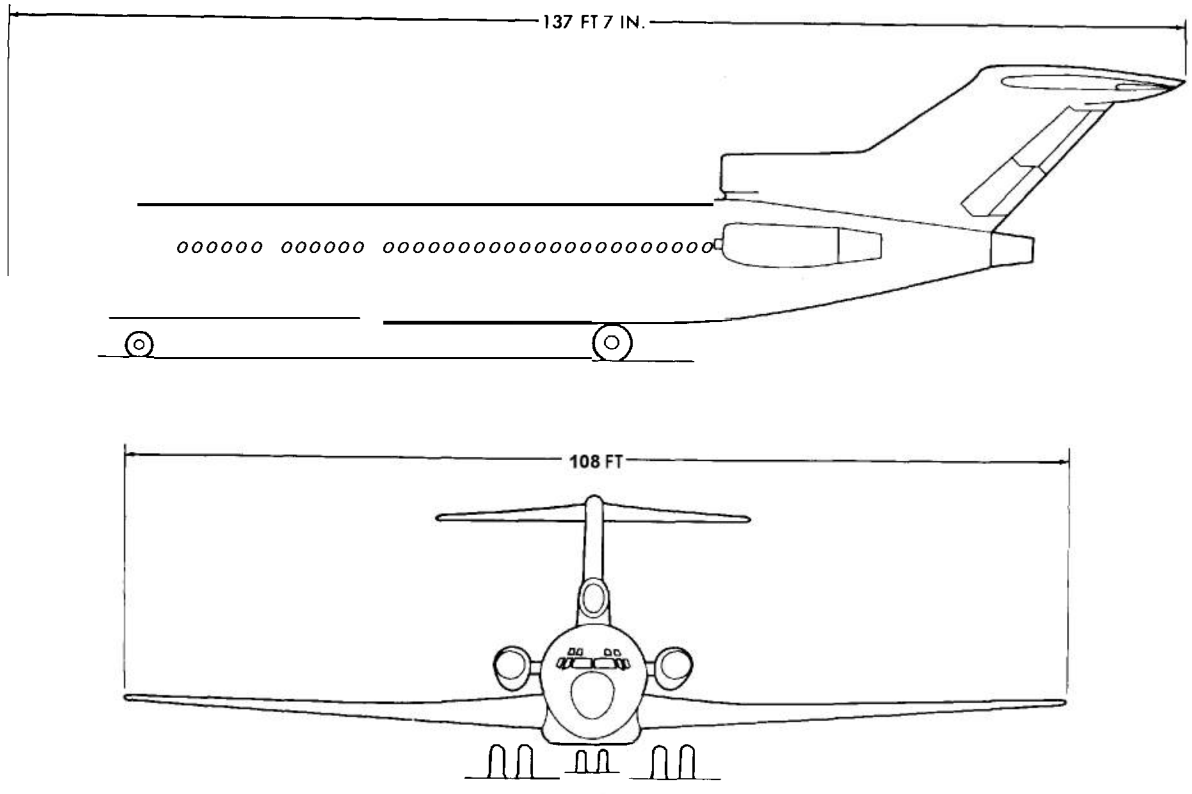


FIGURE 4–139. 727C AND 727QC AIRCRAFT

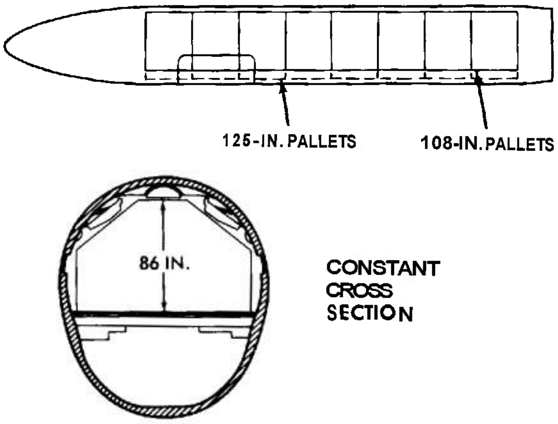


FIGURE 4-140. MAIN CARGO COMPARTMENT, 727C AND 727QC AIRCRAFT

load of 1000 pounds distributed over a 3- by 3-inch area can be sustained providing a 30-inch minimum spacing is maintained between areas. Distributed loads of 8000 pounds may be accommodated with minimum centerline spacing of 79 inches. Distributed loads of 10,000 pounds can be sustained within a floor space of 90 inches minimum width and 40 inches minimum length if centerline spacing is maintained at 110 inches between each 10,000 pounds. Wheeled vehicles must straddle aircraft centerline and individual wheel loading should not exceed 2500 pounds applied through a pneumatic tire inflated to 100 pounds per square inch. Lower forward and aft cargo compartments are lined with a nonporous, damage-resistant material.

4—139.2 ANCHORING ARRANGEMENT. A system of cargo handling guide rails and rollers extends the length of the main cargo compartment. Fixed side guides and pallet locks provide 9 g restraint for palletized cargo in 727C aircraft and 3 g restraint for palletized cargo in 727QC aircraft. A barrier net, designed for 9 g restraint of a full cargo load, is provided with 727QC aircraft. All fixed side guides on 727C aircraft are designed to accept snap-in tiedown fittings to provide restraint for bulk cargo.

4—140 CARGO DOORS

The main cargo door is located on the left side of the fuselage forward of the wing

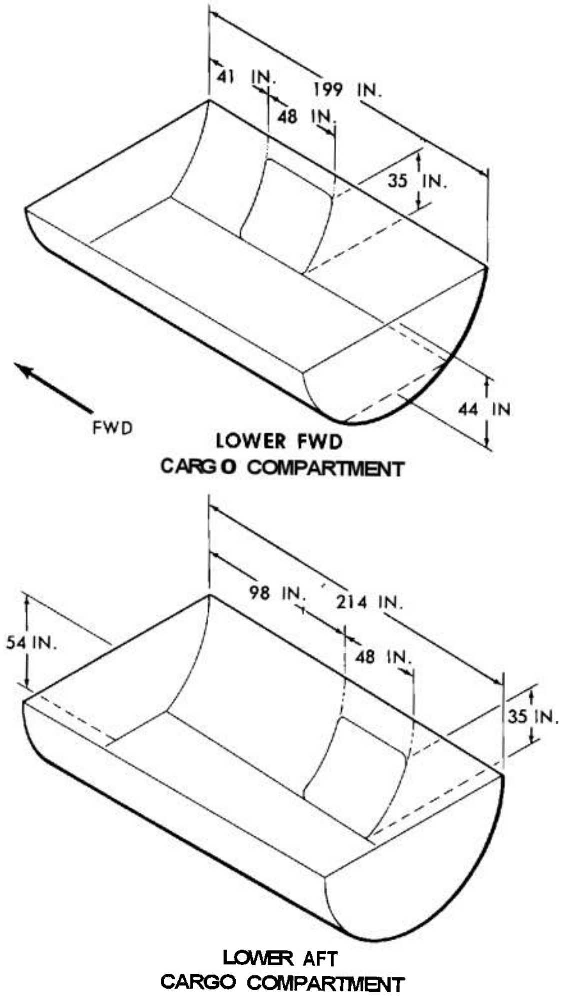


FIGURE 4-141. LOWER FORWARD AND AFT CARGO COMPARTMENTS, 727C AND 727QC AIRCRAFT

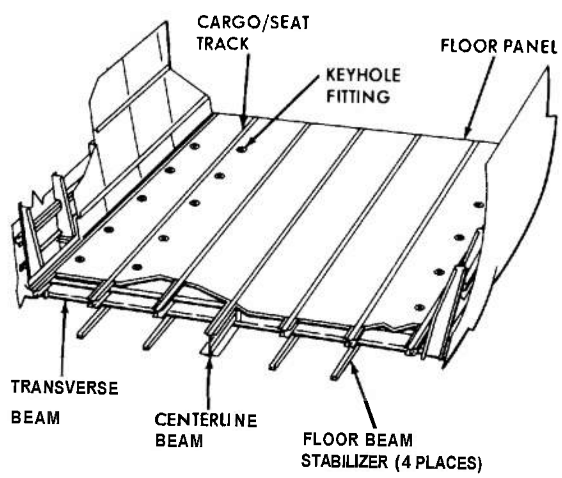


FIGURE 4-142. MAIN CARGO COMPARTMENT FLOOR, 727C AND 727QC AIRCRAFT

(Fig. 4—143). The door sill is at floor height to facilitate pallet loading. The main cargo door can be opened to two positions. With the door in the fully open position, large packages can be crane-lifted and lowered vertically into the aircraft. The door is stopped and held automatically in the canopy position for loading palletized cargo.

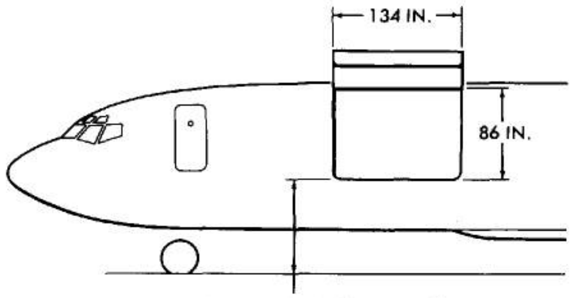


FIGURE 4–143. MAIN CARGO DOOR, 727C AND 727QC AIRCRAFT

Cargo doors for the lower forward and aft cargo compartments are shown in Fig. 4—141.

4—141 RESTRAINT CRITERIA

The cargo handling system on 727C aircraft provides 9 g restraint. The cargo handling system on 727QC aircraft provides 3 g restraint. A 9 g barrier net is provided with 727QC aircraft.

4—142 CARGO LOADING AND UNLOADING PROVISIONS

A ball transfer panel is located adjacent to the main cargo door to provide omnidirectional movement of pallets into the aircraft. Pallets are moved within the aircraft on a floor-mounted conveyor system.

SECTION XXX

CL-44

4—143 GENERAL DESCRIPTION

The Canadair CL-44 aircraft is a four-engine, turboprop, long-range transport (Fig. 4—144). Maximum gross weight of the aircraft is 205,000 pounds, and is designed to carry a maximum net payload of 62,700 pounds. The CL-44 aircraft was specifically designed to carry cargo; passenger seats are not supplied. Special features of the aircraft are cargo compartment pressurization, inflight and ground air conditioning, and a swing tail fuselage. An internal winching system designed to accommodate 122-inch slide pallets is permanently installed in the aircraft. Various types of containers for weather protection and preloading are provided. The CL-44 can be converted to receive standard 88- by 108-inch military pallets, with four roller tracks for loading.

4—144 CARGO COMPARTMENT

The main cargo compartment (excluding tail compartment), extends from station 233 to station 1232.9. It is approximately 137 inches wide and 82.5 inches high. Dimensions are slightly lower at the aft wing spar former. The floor area for the main cargo compartment is 924 square feet. The main cargo compartment has a volume of 5528 cubic feet. Total volume of all cargo compartments is 7226 cubic feet.

The forward underfloor cargo compartment, from station 159 to station 590, is 54.75 inches wide, and 40 inches high. It has a floor area of 162 square feet.

The aft underfloor compartment is 462.5 inches long, 54.75 inches wide, and 40 inches high. The aft underfloor compartment has a floor area of 173 square feet.

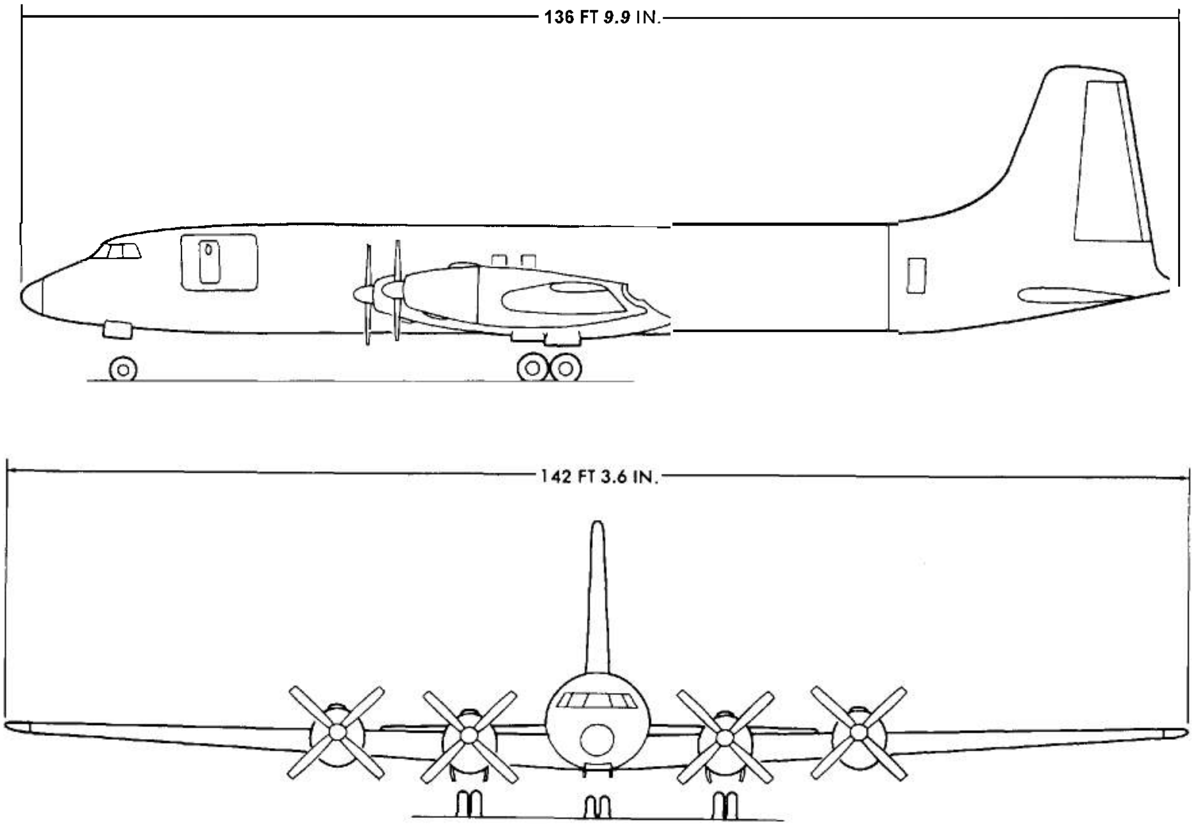


FIGURE 4—144. CL-44 AIRCRAFT

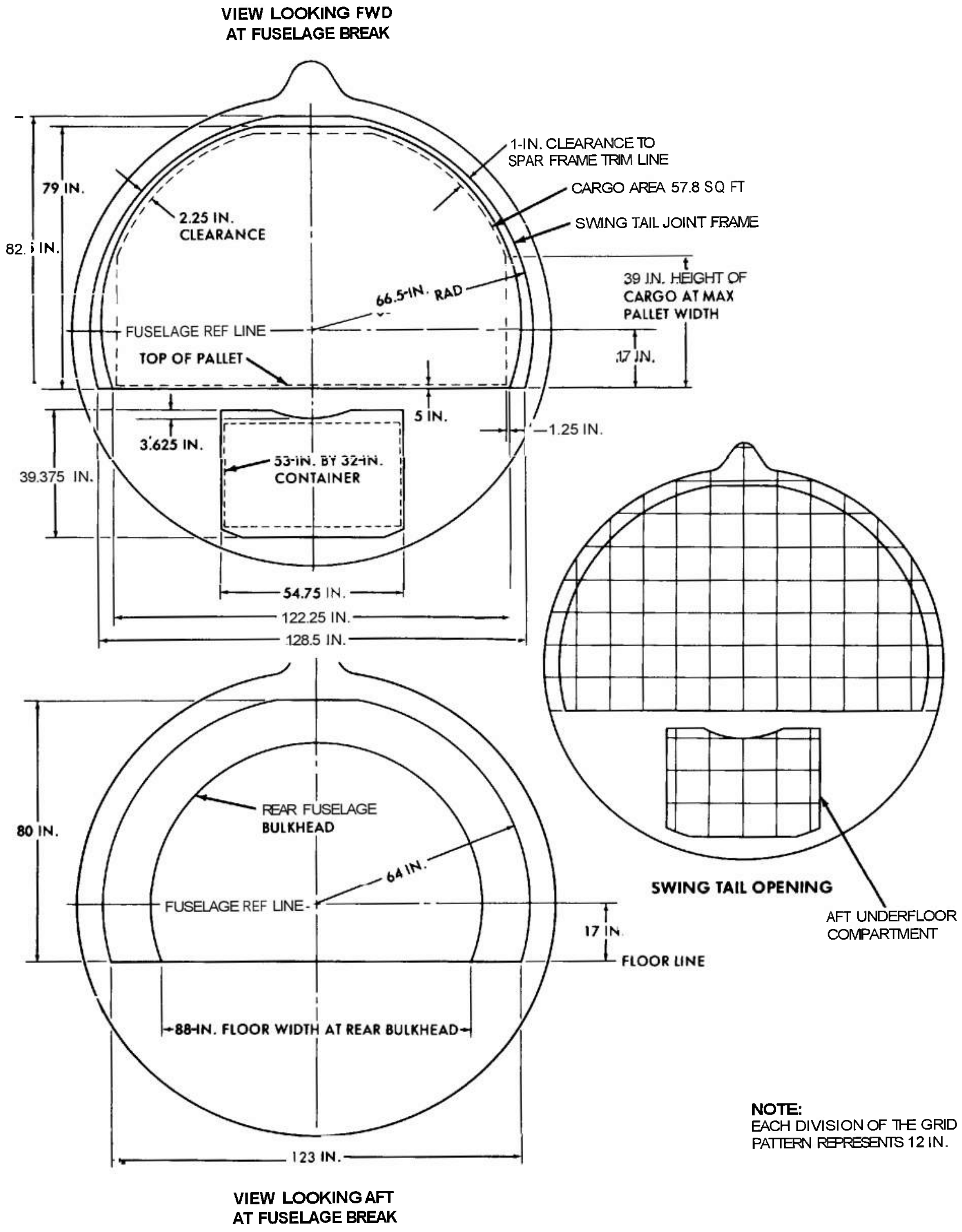


FIGURE 4-145. CARGO COMPARTMENT DIMENSIONS AND CONTOURS, CL-44 AIRCRAFT

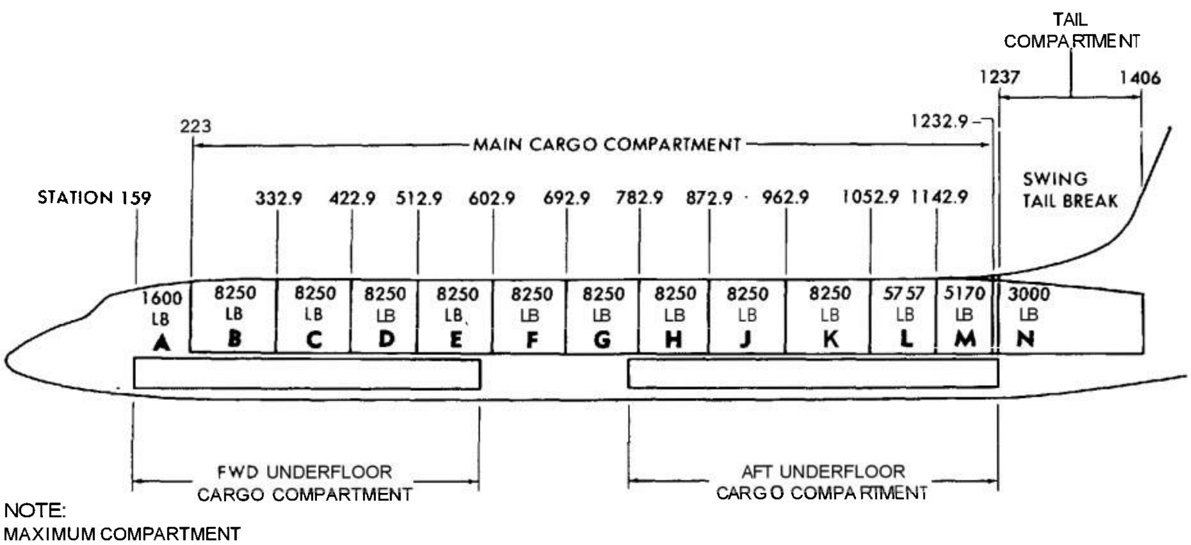
The tail compartment, aft of the swing tail break, from station 1237 to station 1406, is 169 inches long and has a maximum width and height of 129 inches and 81 inches, respectively. Floor area of the tail compartment is 128 square feet. Critical dimensions and contours of the cargo compartment are shown in Fig. 4—145.

4—144.1 FLOOR LOADING. Flooring for the main cargo compartment consists of fire-resistant plywood panels supported by aluminum alloy transverse beams, overlapped by six longitudinal beams. Each of the six longitudinal beams has tiedown receptacles at 1-inch intervals. Fuselage frames support the honeycomb sandwich flooring in the underfloor compartments and the transverse floor beams for the main cargo compartment. The maximum floor loading for the main cargo compartment is 200 pounds per square foot with 300 pounds per square foot permissible over the wing area. The underfloor compartments will support a distributed load of 75 pounds per square foot. Individual cargo compartment weight limitations are shown in Fig. 4—146.

4—144.2 ANCHORING ARRANGEMENT. The main cargo compartment is equipped with six tiedown tracks (Fig. 4—147), capable of receiving tiedown fittings at 1-inch intervals. The four center tracks, which extend to the back of the tail compartment, are rated at 5000 pounds restraint capacity per fitting when fittings are installed a minimum of 20 inches apart. The two outer tracks are rated at 10,000 pounds capacity per fitting, with 20-inch spacing between fittings. The main cargo compartment is also equipped with 48 permanent tiedown fittings, 7 along the left wall and 41 along the right wall. Fittings for securing barrier nets are installed around the periphery of the fuselage at eight locations. Cargo in the underfloor compartment is packed in containers which are restrained by floor hooks and angles on each side of the compartment.

4—145 CARGO DOORS

Palletized cargo is loaded through the swing tail opening. The tail can be opened through 105 degrees in approximately 2 minutes and closed and locked in 1-1/2 minutes.



NOTE:
MAXIMUM COMPARTMENT LOAD INCLUDES UNDERFLOOR COMPARTMENTS.

FIGURE 4-146. CARGO COMPARTMENT WEIGHT LIMITS, CL-44 AIRCRAFT

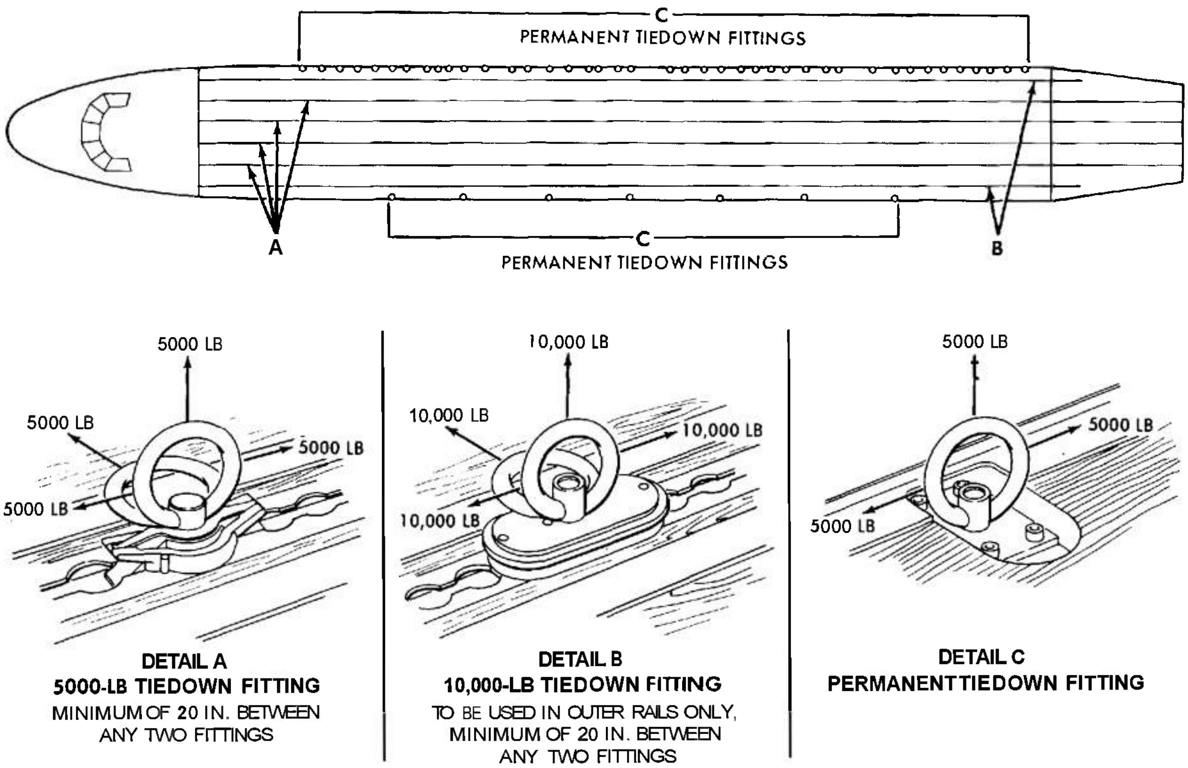


FIGURE 4–147. ANCHORING ARRANGEMENT, CL-44 AIRCRAFT

A hydraulically operated forward cargo door is located on the left side of the aircraft forward of the wing (Fig. 4—148). The forward cargo door provides an opening 73 inches high by 93 inches wide. This door is approximately 10 feet above ground level. Figure 4—149 indicates the maximum package size that can be loaded through this door.

The forward underfloor compartment door is located on the right side of the aircraft between stations 229 and 281. The forward underfloor compartment door provides an opening 52 inches wide by 30 inches high. Figure 4—150 indicates maximum package size for loading through the forward underfloor compartment door.

The aft underfloor compartment door is located on the right side of the aircraft between stations 1020 and 1072. The aft underfloor compartment door provides an opening 52 inches wide by 30 inches high. Figure 4—151 indicates maximum package size for loading through the aft underfloor compartment door.

4—146 RESTRAINT CRITERIA

Restraint for normal fore and aft loads in the CL-44 aircraft is provided by barrier nets, capable of withstanding a 9 g forward crash load. Restraint for side and upward loads is provided by the pallet guide rails.

A147 CARGO LOADING AND UNLOADING PROVISIONS

4—147.1 WINCHING SYSTEM. Internal pallet winching in the aircraft is provided by a hydraulically powered chain and cable system running down either side of the main compartment above floor level. The winching system is normally powered from an external source but can be powered from the swing tail hydraulic system. Maximum pallet winching speed is 12 inches per second in either direction.

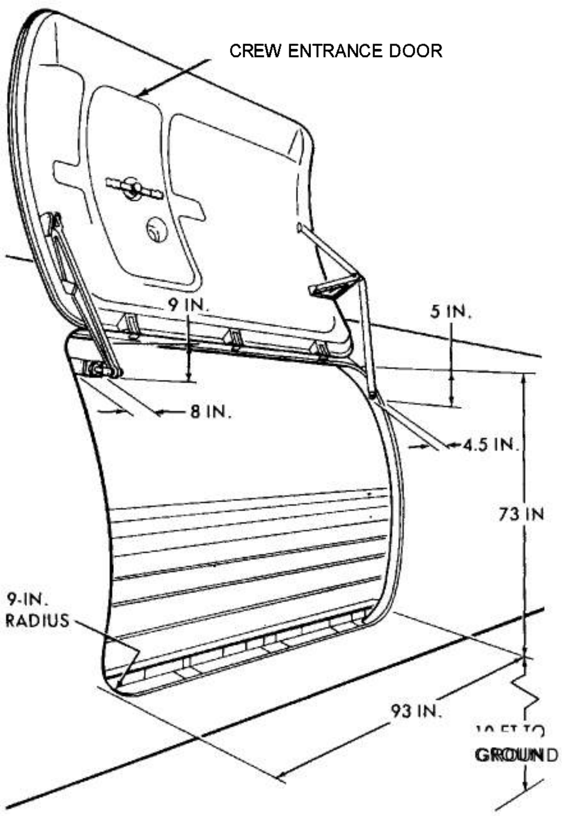


FIGURE 4–148. FORWARD CARGO DOOR, CL-44 AIRCRAFT

4—147.2 PORTABLE CRANE. An electrically operated portable crane, capable of lifting 1000 pounds of cargo from ground level to door sill height, is available with the aircraft. The base of the crane may also be used as a portable winch, capable of winching 6000 pounds at 10 feet per minute.

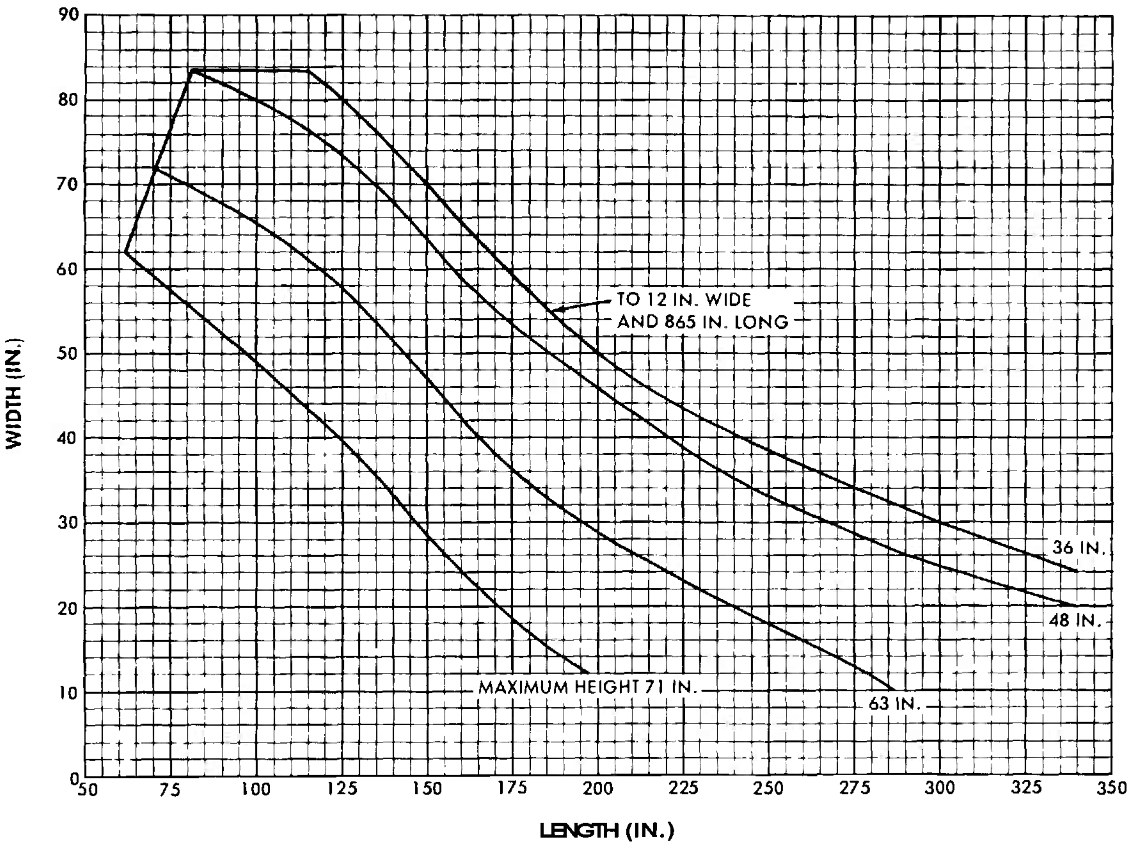


FIGURE 4–149. FORWARD CARGO DOOR PACKAGE SIZE GRAPH, CL-44 AIRCRAFT

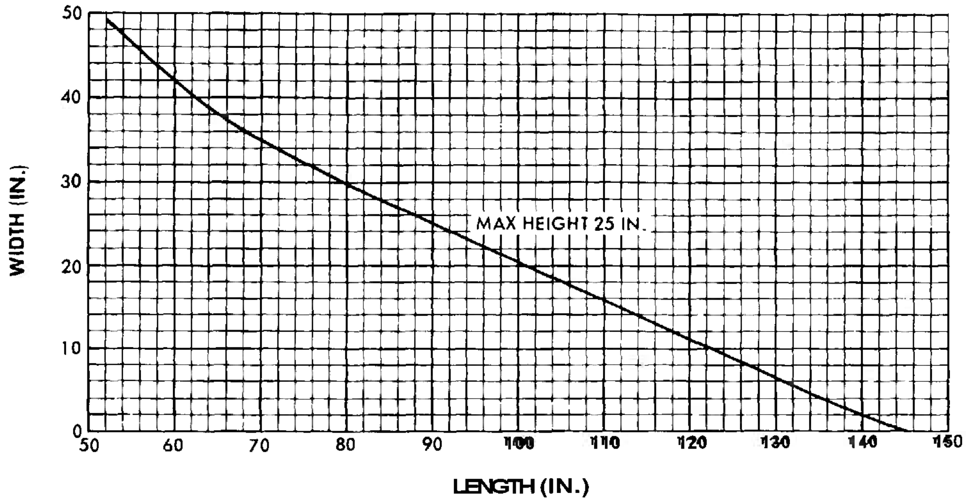


FIGURE 4–150. FORWARD UNDERFLOOR CARGO COMPARTMENT DOOR PACKAGE SIZE GRAPH, CL-44 AIRCRAFT

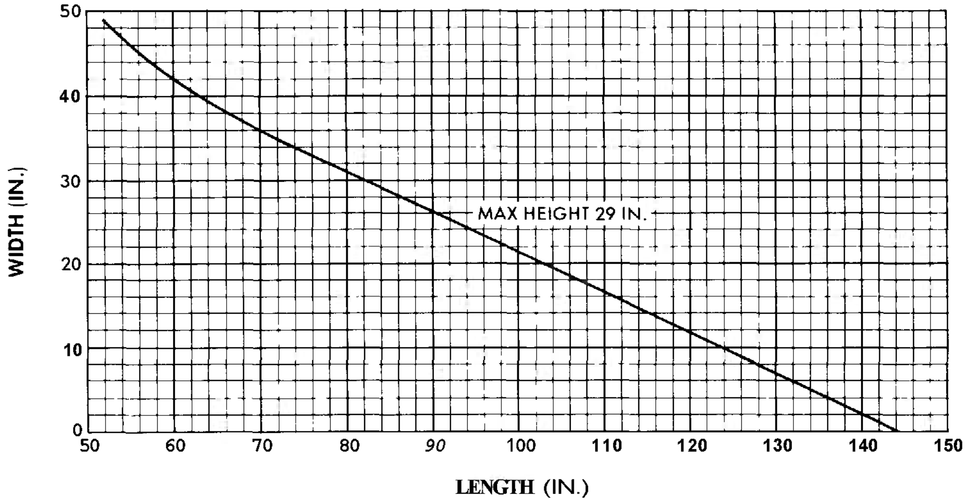


FIGURE 4-151. AFT UNDERFLOOR CARGO COMPARTMENT DOOR PACKAGE SIZE GRAPH, CL-44 AIRCRAFT

SECTION XXXI

ARGOSY 650, SERIES 100

4—148 GENERAL DESCRIPTION

The Argosy 650, series 100, is a high wing, four turboprop engine, twin boom, medium transport (Fig. **4—152**). The double end loading fuselage permits fast turnarounds and conversion to a mixed passenger/cargo role. The Argosy has a range of approximately **600** miles with a **27,000**-pound load.

4—149 CARGO COMPARTMENT

The Argosy **650** cargo compartment extends the full length of the fuselage, including a small area in each freight door. Cargo compartment dimensions are **46** feet **8** inches long, 10 feet wide, and **6** feet 8 inches high minimum. Volume of the cargo compartment is **3680** cubic feet. It has a **426** square foot floor. area and a sill height of **4** feet. Maximum payload is **28,000** pounds.

4—149.1 FLOOR LOADING. The cargo floor was designed to withstand a bulk load of 350 pounds per square foot. Maximum floor loading for the freight doors is ***200*** pounds per square foot. Maximum individual compartment capacities are shown in Fig. **4—153.**

4—149.2 ANCHORING ARRANGEMENT. The cargo floor has 2000-pound tiedown pints at two-inch spacings.

4—150 CARGO DOORS

The forward cargo door provides an opening **8** feet **4** inches wide by **6** feet **8** inches high. The rear door provides an opening ***8*** feet ***8*** inches wide by ***6*** feet ***8*** inches high. Both doors are hinged on the right side of the aircraft.

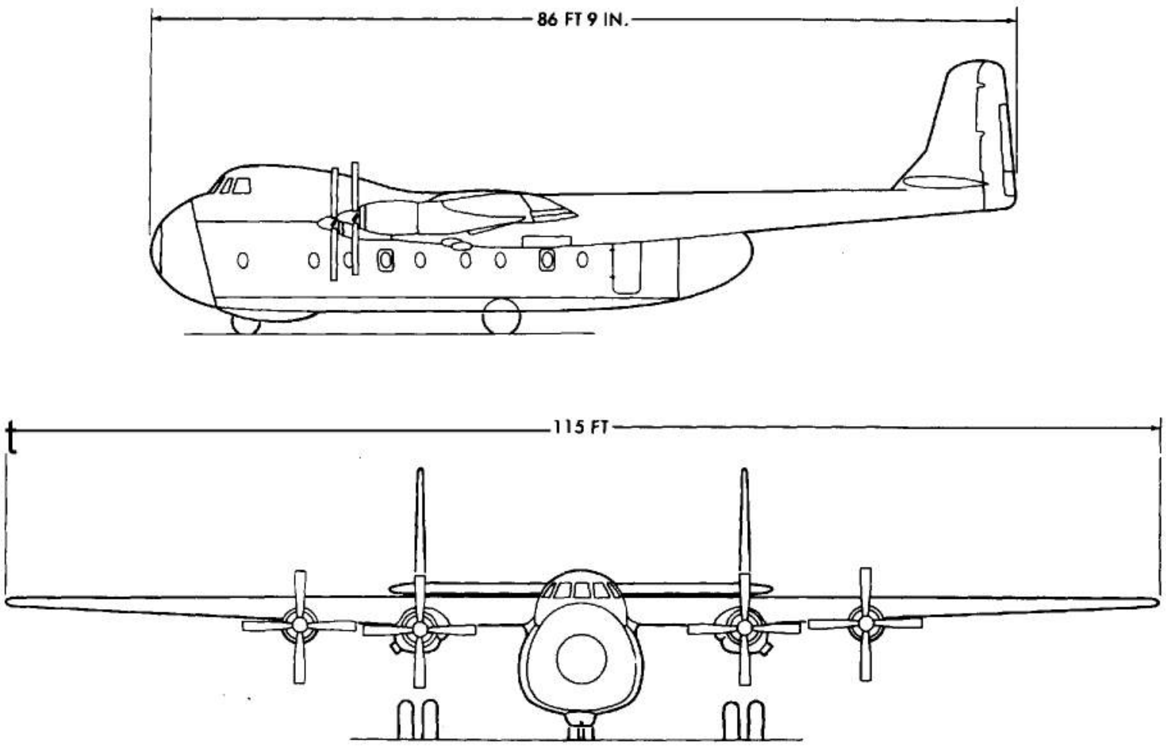
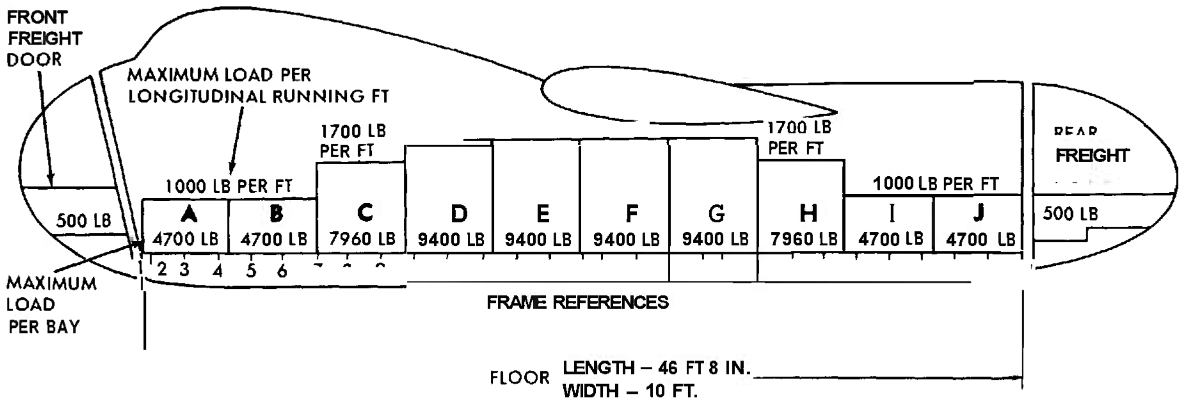


FIGURE 4–152. ARGOSY 650 AIRCRAFT



NOTE:
LOCAL FLOOR LOADS MUST NOT EXCEED 350 LB PER SQUARE FT IN THE FUSELAGE, 200 LB PER SQUARE FT IN THE FREIGHT DOORS.

FIGURE 4–153. CARGO COMPARTMENT DIMENSIONS AND WEIGHT LIMITS, ARGOSY 650 AIRCRAFT

GLOSSARY

Air Delivery Container. A sling, bag, or roll, usually of canvas or webbing, designed to hold supplies and equipment for air delivery.

Air Delivery System. A system designed to facilitate the delivery of personnel, supplies, and equipment from aircraft. These systems are usually comprised of such items as parachutes, air delivery containers, platforms, tiedown devices, and related items.

Airborne Operation. An operation involving the movement and delivery by air, into an objective area, of combat forces and their logistic support for execution of a tactical or a strategic mission. The means employed may be any combination of airborne units, air transportable units, and types of transport aircraft, depending on the mission and the overall situation.

Airdrop. The unloading of personnel or materiel from aircraft in flight. See also: High Velocity Airdrop, Low Velocity Airdrop.

Airdrop Weight. The weight of the item, including external or internal loads such as fuel, ammunition, field gear, or rations.

Anchor Cable. A, cable in an aircraft to which the parachute static line or straps are attached.

Breakcord. A thread or tape tied between parachute components that is intended to break under desired load during deployment.

Bundles. Material to be airdropped which is handled in and ejected from the aircraft solely by personnel. The maximum bundle weight shall be 500 pounds, and the minimum shall give a loading greater than 35 pounds per square foot.

Canopy. Supporting cloth surface of a parachute.

Cluster. A group of two or more parachutes that are attached to a single load and designed to open simultaneously.

Computed Air Release Point (CARP). A computed air position at which paratroops or equipment supply containers are released to land on a specified impact point.

Container. *See:* Air Delivery Container.

Cutter, Reefing Line. A device designed to cut through the reefing line of a canopy. It normally incorporates a delay device (mechanical or pyrotechnical), a power device (mechanical or pyrotechnical), and a knife-edge cutter.

Deployment, That portion of a parachute's operation occurring from the initiation of ejection to the instant the lines are fully stretched, but prior to the initial inflation of the canopy.

Deployment Bag. A container, usually of fabric, which has the primary function of retaining the suspension lines until activation of the deployment system dictates their release. On some parachutes, the deployment bag also contains the canopy.

Deployment Time. See: Time, Deployment,

Diameter, Constructed (D_c). A designation of the size of a canopy, based upon design dimensions.

Diameter, Nominal, (D_o). The calculated diameter of any parachute canopy design which is equivalent to the diameter of a circle whose total area is equal to the total fabric area of the drag-producing surface. Included in the total fabric area are all elements of surface area, including all openings (slots and vents).

Diameter, Projected, (D_p). The mean diameter of the inflated parachute canopy, measured in the plane of the maximum cross section area. On canopies where the fabric curves out between the suspension lines, the projected diameter is the mean diameter of the inner and outer diameters.

GLOSSARY (Cont)

Disconnect, Ground. A device that instantaneously releases the parachute canopy from the suspended load upon ground contact. This device may be actuated electrically, by the action of ground-contact switches or g-sensing devices; or it may be entirely mechanical and sensitive to canopy-load reduction.

Drift. The horizontal displacement of a parachute-store system during descent as caused by crosswinds or by glide instability of the canopy.

Drop Altitude. Actual altitude of an aircraft above the ground at the time of initiation of an airdrop operation.

Drop Zone. A specified area upon which airborne troops, equipment, and supplies are dropped by parachute, or on which supplies and equipment may be delivered by free fall.

Energy Dissipater. A material used to dissipate kinetic energy during impact. Paper honeycomb, Military Specification MIL-H-9884, is the approved energy dissipater for airdrop operations. Paper honeycomb dissipates the kinetic energy by crushing.

Equivalent Drop Height. The height from which a load may be dropped in free fall to achieve the same impact velocity experienced in a parachute drop.

Extraction Provision. An integral fitting on the item used for attaching the extraction system.

Extraction System. A system used to withdraw airdrop items from aircraft in flight.

Filling Time. *See:* Time, Filling.

Finite-Mass Condition. A state of parachute operation. Use of this condition in calculation of filling time and opening shock of canopies stipulates that the velocity decay during inflation is substantial and must, therefore, be considered in the calculation.

Force, Snatch. A force of short duration that is imposed by the sudden acceleration of the parachute canopy mass at the instant of complete extension of the suspension lines or similar components of a parachute system prior to inflation of the canopy.

General Cargo. Cargo which is susceptible to loading in any place, such as boxes, bales, barrels, crates, packages, bundles, and pallets.

Gore. That portion of the parachute canopy between any two consecutive canopy lines; it is usually divided into sections. The manner in which the sections and gores are cut from the material determine the type of canopy construction.

Gross Rigged Weight. The airdrop weight plus the weight of all airdrop rigging. Gross rigged weight = approximately 1200 + 1.16 x airdrop weight.

Gross Weight, Aircraft. Total weight of the loaded aircraft and its contents.

High Velocity Airdrop. Airdrop without conventional recovery parachutes, usually using small stabilizing parachutes, at a terminal velocity of approximately 70 to 90 feet per second. ***See also:*** Airdrop and Low Velocity Airdrop.

Infinite-mass Condition. In the analysis of the dynamics of parachute opening, the approach which stipulates that the velocity of the parachute-load configuration does not change appreciably during the period of canopy inflation, and can therefore be considered constant.

Limit Load. The maximum working force to which the provision will be subjectedunder normal use condition. Limit load for tiedown provisions is defined as that working force which could be encountered when the tiedown provision is subjected to the 4 g flight safety restraint criteria.

Load Spreader. A device for increasing the bearing area of a concentrated load. It may be used between either a wheel, frame, or other member and the energy dissipater to assume crushing of the desired dissipater area.

GLOSSARY (Cont)

Low Velocity Airdrop. The delivery of personnel, supplies, or equipment from aircraft in flight, utilizing sufficient parachute retardation to prevent injury or damage upon ground impact. The nominal terminal velocity of low velocity airdrop is 28.5 feet per second. See also: Airdrop and High Velocity Airdrop.

Malfunction Drop. A malfunction drop is one in which the air delivery equipment does not perform as intended; typical are the complete or partial failure of a parachute to achieve proper opening and descent or contents falling free of pack or platform load.

Opening Time. See: Time, Opening.

Palletized. Quantity of any items, packaged or unpackaged, which is arranged on a pallet in a specified manner and securely strapped or fastened thereto so that the whole is handled as a unit.

Paraglider. A flexible, delta-shaped wing that is made by suspending a flexible membrane between a rigid keel and each of two rigid leading edges.

Platform. A metal or wooden skid designed to hold bulk supplies and heavy equipment for airdrop.

Propellant Actuated Device (PAD). A compact, self-contained package which utilizes the energy generated by the burning of propellant charges to actuate such equipment as reefing line cutters and similar type items.

Rate of Descent. The vertical velocity, in feet per second, of a descending object.

Reefing, Skirt. A restriction of the skirt of the parachute surface to a diameter less than its diameter when it is fully infiated. Reefing is used to decrease the opening shock, to decrease drag area, and to enhance stability.

Reefing, Vent. A means of altering the inflated shape of the parachute canopy by pulling down the vent. This type of reefing may be used to change the drag area and to enhance stability.

Restraint Factor. The amount of restraint, expressed in units of gravity, or g's, to prevent movement of cargo in a specific direction.

Retardation System. A system used to retard and stabilize the descent of an airdropped item.

Rigging. The method of preparing a particular piece of equipment or loadofsupplies for airdrop.

Riser. That part of the personnel parachute harness that extends between the shoulder adapters and the connector links where the suspension lines of the parachute canopy are attached to the harness. That part of the cargo parachute which extends between the snap fasteners or point of attachment to the load and the point of attachment of the parachute canopy suspension lines.

Shock, Opening. The maximum force developed during inflation of the parachute canopy.

Shoring. Lumber, planking, or similar material used for weight spreading, load support, and protecting of aircraft floors.

Skirt, The reinforced hem forming the periphery of a parachute canopy.

Squidding. A state of incomplete canopy inflation in which the canopy has a pear-like or squid-like shape. Squidding occurs if the canopy is deployed above a critical speed.

Standard Load. All loads for which technical manuals (Army) and/or technical orders (Air Force) have been established.

Station Number. A vertical plane representing a distance from the reference datum line measured along the longitudinal axis of the airdrop, or a line parallel thereto.

GLOSSARY (Cont)

Suspended Weight. The gross rigged weight less the weight of the retardation system. Suspended weight = approximately 1200 + 1.07 x airdrop weight.

Suspension Provision. An integral fitting on the item for attaching the retardation system.

Tiedown Device. A device used to lash cargo to tiedown rings in aircraft or to airdrop platforms or skids.

Tiedown Provisions. An integral fitting or part of an item for restraining the item to an airdrop platform or to the aircraft floor using tiedown devices.

Time, Deployment. The time elapsed between pads opening or parachute ejection and extension of the suspension lines.

Time, Filling. The time elapsed between the full extension of the suspension lines (after canopy deployment) and the opening of the canopy to its fullest extent.

Time, Opening. The elapsed time between the initiation of canopy deployment and the opening of the canopy to its fullest extent.

Ultimate Strength. The maximum force which a provision must withstand before breaking failure occurs.

Yield Strength. The force at which a provision exhibits a permanent deformation or set of 0.002 inch per inch in the direction of force application.

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*The Materials Series is being published as Military Handbooks (MIL-HDBK-) which are available to Department of Defense Agencies from the Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.